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Trench 1 Waste Characterization And Disposition Pathways Analysis Report

RF/RMRS-99-303.UN

March 4, 1999
Revision 1

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Trench 1 Waste Characterization and Disposition Pathways Analysis Report

Rocky Mountain Remediation Services, L.L.C.
and
Kaiser-Hill, L.L.C.
Rocky Flats Environmental Technology Site
Golden, Colorado

March 4, 1999
Revision 1

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EXECUTIVE SUMMARY

The remediation of Trench 1 (T-1) at the Rocky Flats Environmental Technology Site (RFETS) was conducted in accordance with the Proposed Action Memorandum (PAM) for the Source Removal at T-1 (RMRS, 1998a). Excavation of the trench was performed during the period June 1998 through August 1998. Several waste streams were generated from the source removal including radioactive metal wastes, cemented cyanide wastes, contaminated soils, decanted lathe coolant, and debris. All wastes have been safely containerized and are currently stored within a Temporary Unit at the T-1 project site.

This report presents the characterization of the T-1 waste streams and evaluates treatment alternatives for those wastes that cannot be directly land disposed, i.e., exceed Land Disposal Restrictions (LDRs). This report concludes with a presentation of a proposed disposition strategy for the T-1 waste streams. The disposition pathways proposed are based on the characterization of the wastes and the evaluations of offsite and onsite treatment alternatives and are summarized as follows:

I. Direct Land Disposal

Waste Stream	Characterization	Proposed Disposition
DU Ingot and Project-Generated Debris	LLW	Land Disposal at Nevada Test Site
Soil (LDR-Compliant)	LLW/RCRA/TSCA	Land Disposal at Envirocare
Excavated Debris	LLW/RCRA/TSCA	Land Disposal at Envirocare

II. Treatment and Disposal

Waste Stream	Characterization	Proposed Disposition
Decanted Lathe Coolant		
Aqueous Liquid	LLW/RCRA/TSCA	Treatment at RFETS CWTF
Organic Liquid	LLW/RCRA/TSCA	Offsite Storage and Treatment
Cemented Cyanide Waste	LLW/RCRA/ACM	Offsite Storage and Treatment
Radioactive Metals and Soil (non-LDR-Compliant)	LLW/RCRA/TSCA	Offsite Storage and Treatment

CWTF	Consolidated Water Treatment Facility
LLW	Low Level Waste
RCRA	Resource Conservation and Recovery Act
TSCA	Toxic Substances Control Act

The T-1 waste streams listed in Part I of the above table (i.e., the depleted uranium [DU] ingot, project-generated debris, and LDR-compliant soil) meet LDRs and will be disposed at the Nevada Test Site (NTS) or Envirocare as LLW and LLW/RCRA/TSCA mixed waste, respectively. The waste streams listed in Part B of the table (i.e., lathe coolant, cemented cyanide, radioactive metal, and non-LDR-

compliant soil) do not meet LDRs and must be treated. The aqueous-phase lathe coolant is the only waste that is able to be treated at RFETS and will be treated at the Building 891 Consolidated Water Treatment Facility (CWTF).

Several offsite and onsite alternatives were examined for the remainder of the non-LDR-compliant mixed wastes. Offsite treatment at both commercial facilities and several mixed waste treatment facilities currently operated within the DOE Complex was evaluated. The DOE facilities included the TSCA Incinerator at Oak Ridge National Laboratory (ORNL), the M-Area Vitrification Plant at Savannah River Plant (SRP), and the Waste Experimental Reduction Facility (WERF) at the Idaho National Engineering Laboratory (INEL). The TSCA Incinerator is technically capable of treating the Trench 1 wastes, but is not an option at this time because of a current moratorium imposed by the State of Tennessee blocking the acceptance of out-of-state wastes. The time frame for the removal of this moratorium is unknown. The M-Area Vitrification Plant and the WERF are also not feasible offsite treatment options. The Trench 1 radioactive metal wastes do not meet the waste acceptance criteria of either of these facilities.

The commercial offsite facilities evaluated include:

- Materials and Energy Corporation (M&EC) in Oak Ridge, Tennessee;
- Allied Technical Group (ATG) in Richland, Washington;
- Perma-Fix Environmental Services in Gainesville, Florida;
- Diversified Scientific Services, Inc. (DSSI) in Kingston, Tennessee;
- Starmet Corporation in Barnwell, South Carolina;
- Waste Control Specialists (WCS) in Andrew, Texas; and
- Envirocare of Utah, in Clive, Utah.

None of the seven commercial facilities listed above currently possess all of the necessary permits and licenses to treat the T-1 radioactive metal, soil, and cemented cyanide wastes. Two facilities, Perma-Fix and WCS, appear to be within six months away from obtaining the required permits and license modifications to treat the cemented cyanide waste. All seven of the commercial facilities identified could treat the cyanide waste under the RCRA Treatability Exclusion. A thorough evaluation will be completed to select the most appropriate commercial facility to treat the cyanide wastes. Barring any unforeseen circumstance, offsite shipment of these wastes will be completed prior to the end of Fiscal Year 1999.

Four of the commercial facilities listed above are currently working toward regulatory approval that will allow treatment of the T-1 radioactive metal and soil wastes: M&EC, ATG – Richland, Perma-Fix, and WCS. It is estimated that each of these facilities is approximately 12 to 24 months away from receiving authorization to treat LLW/RCRA/TSCA wastes. However, thee four facilities are presently permitted or should be permitted this fiscal year for the storage of the T-1 radioactive metal and soil wastes. A thorough evaluation will be completed to select the most appropriate commercial facility for interim storage and future treatment of the radioactive metal and soil wastes. A contractual arrangement with a commercial facility for storage and future treatment and disposal of the wastes will be pursued this fiscal year.

Alternatives evaluated for the onsite treatment of the radioactive metal and soil wastes include a variety of technologies including steam reforming, dechlorination, stabilization, solvent extraction/direct chemical oxidation, thermal desorption and oxidation, and vitrification. The evaluations indicated that onsite treatment using batch vitrification or steam reforming is technically feasible, but was eliminated from consideration at this time because of Clean Air Act issues, treatability testing requirements, and the negative public perception associated with operating thermal processes.

Safe interim storage and future treatment and disposal at an approved and permitted offsite commercial facility is the best path forward for the radioactive metal and soil waste streams. A contractual arrangement with a commercial facility for storage and future treatment and disposal of the wastes will be pursued this fiscal year. In the event that the pursuit of this strategy proves to not be viable, investigation of longer term storage of T-1 wastes at RFETS will be investigated.

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ACRONYMS

Ac	Actinium
Am	Americium
ACM	asbestos containing materials
AEC	Atomic Energy Commission
ATG	Allied Technology Group
CBD	Commerce Business Daily
CERCLA	Comprehensive Environmental Response Compensation Liability Act
CWTF	consolidated water treatment facility
DCO	direct chemical oxidation
DOE	Department of Energy
DSSI	Diversified Scientific Services, Inc.
DU	depleted uranium
EPA	Environmental Protection Agency
FIDLER	Field Instrument for the Detection of Low Energy Radiation
HASP	Health and Safety Plan
IDLH	immediately dangerous to life and health
INEL	Idaho National Engineering Laboratory
kg	killigram
LANL	Los Alamos National Laboratory
LDR(s)	land disposal restrictions
LLW	low-level waste
M&EC	Materials and Energy Corporation
mg	milligram
NTS	Nevada Test Site
ORNL	Oak Ridge National Laboratory
OVA	organic vapor analyzer
PAM	Proposed Action Memorandum
PCB	polychlorinated byphenyls
PCE	Tetrachloroethene
PPE	personal protective equipment
Pu	Plutonium
RCT(s)	Radiological Control Technicians
RCRA	Resource Conservation and Recovery Act
R&D	research & development
RFETS	Rocky Flats Environmental Technology Site
RMRS	Rocky Mountain Remediation Services, LLC
SAP	Sampling and Analysis Plan
SET	solvated electron technology
SRP	Savannah River Plant
T-1	Trench 1
TCE	Trichloroethene
TCLP	toxicity characteristic leaching procedure
TD	Thermal Desorption
TH	Thorium
TSCA	Toxic Substances Control Act
U	Uranium
VOCs	Volatile Organic Compounds

WCS	Waste Control Specialists
WERF	Waste Experimental Reduction Facility

1.0 INTRODUCTION

Drums of buried waste were recently excavated from Trench 1 (T-1) at the Rocky Flats Environmental Technology Site (RFETS). This excavation was conducted in accordance with the Proposed Action Memorandum (PAM) for the Source Removal at T-1, IHSS 108 (RMRS, 1998a). Several waste streams were generated from this source removal activity including radioactive metal wastes, cemented cyanide waste, contaminated soils, decanted lathe coolant, and debris. These wastes have been safely containerized and are currently being stored on an interim basis at the T-1 project site.

This report evaluates the treatment and disposal alternatives that are currently available for each of the T-1 waste streams. Based on the evaluations, a "path forward" for the disposition of each waste stream is identified. The report first presents a detailed characterization of the T-1 waste streams in Section 2. Sections 3 and 4 identify and evaluate offsite and onsite alternatives, respectively, for the treatment of T-1 wastes that do not meet land disposal restrictions (LDRs). Section 3 examines the regulatory permit and license status of the offsite facilities considered with respect to treating T-1 wastes, and Section 4 investigates the effectiveness, implementability and costs associated with several onsite treatment technologies. Finally, Section 5 summarizes the proposed strategy for dispositioning the T-1 waste streams based on the information and analysis presented in this Report.

2.0 WASTE STREAM CHARACTERIZATION

This section details the characterization of the soils and other waste streams generated by the T-1 Source Removal project. These waste streams were managed in a manner consistent with RFETS policies and procedures and the requirements established by the PAM (RMRS, 1998a). All waste being sent offsite for disposal will be considered CERCLA waste because they were generated by a CERCLA Response Action (under the Rocky Flats Cleanup Agreement), and all but uncontaminated field trash is considered low level radioactive waste (LLW). Tables 2-1 through 2-4 present a summary of the T-1 waste streams including regulatory classification, number and type of containers in which the wastes have been packaged, and the volume and weight of each waste stream. The T-1 waste streams include:

- Radioactive Metals.
- Cemented Cyanide.
- Soil.
- Decanted Lathe Coolants.
- Debris.

Analytical data summary tables for each of the waste streams listed above are included in Appendix A of this Report and support the waste characterization discussions presented below.

2.1 Radioactive Metals

Most of the radioactive metal wastes removed from T-1 were depleted uranium (DU). Throughout the excavation, project personnel assessed the uranium type (i.e., depleted vs. natural vs. enriched) and the potential presence of transuranic isotopes using gamma spectroscopy. No wastes containing enriched uranium or transuranic isotopes (other than at near detection level activities) were encountered. The following subsections address both the radiological and chemical characterization of the radioactive

metal waste streams.

2.1.1 Depleted Uranium

The primary DU waste stream has been packaged in 154 containers, both overpack drums and B-12 waste boxes as indicated in the first row of Table 2-1. The overpacks consist of 30- and 55-gallon drums recovered by the excavation overpacked into new 55-, 83/85-, and 110-gallon overpack drums as appropriate. The B-12 waste boxes are steel "half crates" with a volume capacity of approximately 1.6 cubic yards.

Characterization data collected during the excavation phase indicated that there was widespread contamination of the DU with chlorinated volatile organic compounds (VOCs), polychlorinated biphenyls (PCBs), and cadmium. The primary chlorinated VOCs detected were tetrachloroethene (PCE) and trichloroethene (TCE), and the only PCB detected was Aroclor-1254.

Extreme variability in chlorinated VOC, PCB and cadmium concentrations in DU samples has important waste management and disposal consequences. It seems reasonable to assume that much of the variability in the organic contaminant concentration data is attributable to the amount of "oil residue" that was present in the DU waste sampled, and that the amount of residue may be variable within an individual drum. It is therefore difficult to accurately determine VOC and PCB concentration levels in an individual drum based on one sample from that drum. Therefore, the DU waste stream is characterized as an entire lot, and not on an individual drum-by-drum basis. It should also be noted that the sampling strategy developed to support the characterization of the DU wastes was based on field segregation of material by physical characteristics or distinct locations within the trench, if possible (Starmet, 1998). The Sampling and Analysis Plan was not intended to address full characterization of individual drums or waste packages. However, differences in physical characteristics and trench locations that would have allowed segregation of individual drums were not apparent during excavation. Because not all drums were sampled for all possible constituents and distinct characteristics or locations were not observed, segregation of the DU wastes was not possible.

The data presented in Appendix A indicate that PCE and TCE were detected in the DU wastes over a range of non-detect (ND) to 20 weight percent and 10 weight percent, respectively. Based on the historic use these solvents at RFETS in machining operations, the DU waste stream is considered to be F001 and F002 (i.e., RCRA F-Listed chlorinated organic solvents). In addition, the waste code D006 (i.e., exceeds RCRA TCLP threshold for cadmium) has been applied because approximately 20 percent of the drums subjected to TCLP testing exceeded the threshold of 1 mg/L for cadmium. Cadmium TCLP values ranged from less than 1 mg/L to 35.06 mg/L. Because the PCB isomer Aroclor-1254 was also detected in the DU wastes (ND to 580 parts per million [ppm]), the DU waste stream is considered to be a PCB Remediation Waste under the Toxic Substances Control Act (TSCA). The TSCA PCB Remediation Waste designation applies to wastes buried prior to April 18, 1978 per 40 CFR 761.3 which is the case for T-1 wastes.

One exception to the DU characterization presented above is the DU ingot or "puck" that was recovered during the excavation. The ingot is one piece of solid stock material approximately 0.5 cubic feet in volume and did not appear to have been previously machined. The ingot was placed into a 55-gallon drum (D93471), inerted/packed with clean soil, and subsequently overpacked into an 83-gallon drum (X10906). The ingot was not sampled because the material was positively identified by one of the

project RCTs familiar with the process of generating DU ingots or "pucks", and that sampling solid DU was not practical with the sampling tools available. Because of its relatively massive nature this waste is not considered pyrophoric, and because it has not been machined (i.e., product stock) contamination is unlikely. Also, the presence of cadmium is unlikely as the ingot was not a finished product and did not appear to have been plated - a probable source of the cadmium contamination. The ingot is considered source material under the Atomic Energy Act, and for the purpose of disposal, it is considered a low-level radioactive waste.

2.1.2 Thorium

Through the use of gamma spectroscopy it was determined that some of the radioactive material removed from T-1 was not DU. Two samples (a regular and a duplicate) used to characterize a drum of radioactive material that was placed into an 83-gallon overpack indicated that the drum contained Thorium-232 (Th-232). The data in Appendix A indicate that Th-232 was detected at approximately 19,700 pCi/g and U-238 was not detected in these samples. Th-232 was quantified through detection of its daughter product Actinium-228 (Ac-228). Considering that the material is approximately 40 years old, the activity detected for Actinium-228 would approximate that of the Th-232 parent material (i.e., the isotopes are in secular equilibrium. The relationship between Ac-228 and Th-232 was confirmed using the computer software RADDECAY (Grove Engineering, 1987). PCE and TCE were detected in a sample of waste from this drum at 100 ppm and 5.5 ppm, respectively, and Aroclor-1254 was detected at 2,200 ppm. The drum of thorium waste will therefore be given F001 F002 and PCB Remediation Waste designations. Although cadmium was not detected in the one sample collected from this drum, additional sampling to fully characterize the contents of this drum and ensure that no cadmium-plated turnings are not present is not recommended because of worker exposure issues. Also, the costs associated with additional sampling would likely be greater than the incremental costs of treating this drum along with the DU waste stream (i.e., stabilizing the thorium wastes for cadmium leachability). A D006 waste code will therefore be assigned to the drum of thorium waste.

A B-12 waste box (X09823) also contains Th-232 waste, and unlike the drum described above, contains DU waste as well. The checklist documenting the filling of this waste box indicates that the B-12 contains the contents of two non-intact drums and soil. The sample log clearly indicates that the sample from the B-12 (Sample Number 98A2105-040) was comprised of two distinct materials and that the results confirm the presence of both thorium and DU. The analytical data presented in Appendix A indicate the presence of Th-232 and U-238 at 4,107 pCi/g and 59,893 pCi/g, respectively. Because of the presence of PCE at 35 ppm, these low-level radioactive wastes have been assigned F001 and F002 waste codes. A sample of this waste was not analyzed for PCBs or cadmium. Considering the absence of these data and the presence of DU in the B-12, this thorium waste will be coded as D006 as well as PCB Remediation Waste.

2.1.3 Historic Samples

Several jars of sample waste were recovered from T-1 and are referred to as "Historic Samples" to differentiate them from T-1 waste characterization samples collected during the excavation. The historic samples were marked as "UH_3" (i.e., uranium hydride) or "Tuballoy". Tuballoy is a term that has been used at RFETS to designate DU.

The UH_3 and tuballoy historic sample wastes were placed in one B-12 waste box (X09829) along with

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soil. The sample jars were broken so that the potentially pyrophoric contents would be effectively inerted by the soil as required by the PAM (RMRS, 1998a). The sample jars and uranium wastes constitute a relatively small proportion of the contents of the B-12, with the remaining volume being soil. Because the historic samples have been mixed, the characterization presented below and in Table 2-1 considers all of the historic sample waste as one lot.

Gamma spectroscopy analysis of the UH_3 sample wastes prior to placement into the B-12 waste box indicated that the wastes were natural uranium. Chemical analysis indicated the presence of PCE (0.23 ppm to 210 ppm). TCE and PCBs were not detected in the sample, and although cadmium was detected, it was not observed to be above the TCLP threshold for this metal. The Tuballoy historical sample wastes were not analyzed, and therefore, the presence of PCBs or cadmium cannot be eliminated. Therefore, the same chemical characterization used for the DU wastes in Section 2.1.1 has been applied to the historical sample wastes.

2.2 Cemented Cyanide

Ten 55-gallon drums of unsolidified cemented cyanide waste were exhumed from the T-1 as indicated in Table 2-2. Samples were collected from each of the ten drums for gamma spectroscopy and cyanide analysis. All results indicated low level U-238 contamination (8.1 to 117 pCi/g) and significant levels of cyanide (0.51 - 5.3 weight percent). Most of the drums appeared to contain asbestos fibers; samples from two drums were analyzed for asbestos and both contained significant amounts of asbestos (15 and 25 volume percent). Four samples were collected from three of the ten drums (this included one duplicate) and were analyzed for VOCs/SVOCs, the complete TCLP list, reactive sulfide, reactive cyanide, corrosivity, and isotopic Pu, Am, U. These samples were also subjected to additional gamma spectroscopy. These four samples are representative of the entire waste stream. A summary of the analytical results follows:

- No VOCs or SVOCs were detected.
- All samples exceeded TCLP thresholds for cadmium (829-1,200 mg/L).
- No other TCLP thresholds were exceeded.
- pH was in the range of 12.4-13.2.
- Reactive Sulfide was not detected.
- Reactive Cyanide: Three of four samples reported as not detected. One sample reported as 0.3 ppm reactive cyanide.

As indicated in the PAM (RMRS, 1998a), the original cyanide generation process could not be established with full confidence. As a result, it was originally planned to rely on the characteristics of the wastes to determine if it was hazardous waste or not. After conducting additional research of historical records, however, the generation process was essentially determined to be a listed electroplating process. The applicable listings are F006 and F008 and are defined as "Wastewater treatment sludges from electroplating operations...", and "Plating bath residues from the bottom of plating baths from electroplating operations where cyanides are used in the process", respectively. Although there are no LDR implications, the waste code D006 is also being added to the cemented cyanides as the waste exceeds the TCLP standard for cadmium. In addition to the RCRA codes F001, F002, and D006, the cemented cyanide wastes are designated as TSCA Asbestos Containing Material

(ACM) based on the results of the asbestos analyses noted earlier.

Also included in the T-1 cemented cyanide waste stream is one drum of debris resulting from the sampling and handling of the cemented cyanide wastes. This debris is comprised of drum lids, rings, sampling equipment, and sampling-related PPE.

2.3 Soil

Soils excavated from T-1 (and not returned as backfill) were segregated using radiological and VOC field-screening techniques into the groups noted in Table 2-1. The field-screening techniques involved measurement of radioactivity and organic vapors with a field instrument for the detection of low energy radiation (FIDLER) and an organic vapor analyzer (OVA), respectively.

Fifty-two B-88 waste boxes were filled with excavated soils that were segregated according to OVA readings less than 25 ppm (i.e., Table 2-3, Rows 1 and 2). The wastes in these containers are considered as one lot based on the segregation achieved by field screening. Twelve samples of these soils were collected for gamma spectroscopy analysis and four samples were collected for full-suite chemical analysis. The resulting analytical data are included in Appendix A. The ranges of contamination produced by these analyses are as follows: U-238 (24.8 to 1,250 pCi/g), PCE (ND to 24 parts per billion [ppb]), and Aroclor-1254 (ND to 0.65 ppm). Based on these results, the waste is considered an LDR-compliant mixed hazardous waste with the following RCRA codes: F001 and F002. In addition, the waste is considered a Bulk PCB Remediation Waste per 40 CFR 761.3 for wastes buried prior to April 18, 1978. These soils will not require treatment prior to land disposal.

Field segregation of excavated soils resulted in eleven B-88 waste boxes of soils with OVA readings greater than 25 ppm (Table 2-3, Row 3). Analysis of one sample from each of the eleven B-88 waste boxes indicated the presence of U-238 (92.4 to 3,980 pCi/g), PCE (0.067 to 51 pCi/g), TCE (ND to 0.13 ppm), and Aroclor-1254 (0.19 to 16 ppm). Based on these results, the waste is considered a non-LDR compliant mixed hazardous waste with the following RCRA codes: F001 and F002. In addition, the waste is considered a Bulk PCB Remediation Waste. The eleven B88s are considered as one lot based on the segregation achieved by field screening, and will require treatment prior to land disposal to address the F001 and F002 constituents.

2.4 Decanted Lathe Coolant

What appeared to be lathe coolant was decanted from a number of intact drums removed from the trench. The lathe coolant was segregated in accordance with the Starmet Sampling and Analysis Plan (SAP) (Starmet, 1998). The lathe coolant was decanted and transferred into three 55-gallon drums as indicated in Table 2-4. Two of the drums (X07938, X07927) contain a aqueous-phase liquids, and the third drum (X07935) contains aqueous-phase and organic-phase liquids.

Laboratory analysis confirmed the presence of uranium, chlorinated VOCs, and PCBs in the lathe coolant, but significant levels of metals were not detected. The results are as follows:

Aqueous-Phase Liquids (Drums X07938 and X07927)

U-238 1,610 – 77,400 pCi/L

PCE	ND – 0.037 mg/L
TCE	ND – 0.024 mg/L
Aroclor-1254	ND – 0.21 mg/L

Aqueous-Phase Liquid (Drum X07935)		Organic-Phase Liquid (Drum X07935)	
U-238	264,000 pCi/L	U-238	125,000 pCi/L
PCE	0.7 mg/L	PCE	2.4 mg/L
TCE	ND	TCE	ND
Aroclor-1254	76 mg/L	Aroclor-1254	112 mg/L

Because of the presence of uranium, PCE, and TCE, and Aroclor-1254, all three drums of decanted lathe coolant are considered to be low-level mixed waste with F001, F002 codes as well as PCB Remediation Waste. A summary of all the analytical data generated for the T-1 decanted lathe coolants are included in Appendix A.

In December 1998 the two drums (X07938, X07927) containing the aqueous-phase liquids were transferred to the RFETS Consolidated Water Treatment Facility (CWTF) in Building 891 for treatment. The third drum (X07935) containing both aqueous and organic phases is currently being stored on an interim basis at the T-1 project site.

2.5 Debris

2.5.1 Excavated Debris

Other than drum carcasses very little debris was encountered during the T-1 excavation. Deteriorated drum carcasses (i.e., fragments), drum lids and drum rings were typically removed from the wastes as practical and visually verified to be free of chips and turnings so that they would be considered non-pyrophoric and free of liquids (i.e., oils). This material was then placed into B-12 or B-88 waste boxes. The other types of debris encountered included a few pieces of pipe, a small volume (i.e., less than 1 cubic foot) of sandpaper and cardboard containers identified as "ice cream cartons" by field personnel. These cardboard containers were apparently used to hold DU floor sweepings from Building 444. Five B-88 waste boxes were filled with debris recovered from T-1 as indicated in Table 2-4.

Because a relatively small volume of debris was excavated from T-1, only a few samples were collected for analysis. One sample was collected for full-suite chemical analysis, along with a few additional samples for gamma spectroscopy analysis. All samples showed evidence of DU contamination. The sample collected for full-suite chemical analysis was from the cardboard "ice cream cartons". This sample contained PCE at 23 ppb, Aroclor-1254 at 730 ppm, and various RCRA metals including cadmium, all well below the TCLP thresholds. As such, the waste is considered an LDR-compliant mixed hazardous waste with the following RCRA codes: F001 and F002. In addition, the waste is considered a PCB Remediation Waste under TSCA. Since much of the debris is comprised of rusty metal fragments, it is not practical to use the RCRA debris standard to exit the RCRA hazardous waste regulations.

The sample of the cardboard "ice cream cartons" likely represents worst case contamination levels in the excavated debris waste stream because it contained DU wastes, is very porous, and hence, was able to absorb contaminants better than the typical metal drum fragment. All debris sample results are contained in the project files for RIN 98A2117.

2.5.2 Project-Generated Debris

Table 2-4 indicates that several waste boxes were filled with debris that was not recovered from T-1, but was generated during the source removal action. This project-generated debris includes plastic liners, empty one-gallon paint cans used to transport T-1 samples, various metal and wood components used within the tent structure, a mineral oil pump, PM-10 air monitors and motor assemblies, spent air filters from the heavy equipment, wooden shovel handles, HEPA cartridges from full face respirators, and spent personal protective equipment (PPE). These materials are considered to be CERCLA and LLW by T-1 Waste Generator personnel. Although samples of the project-generated debris were not collected for analysis, the characterization noted above is consistent with materials used in radiological controlled areas that cannot be economically free-released because of the potential for low level radionuclide contamination in inaccessible or difficult-to-survey areas.

2.6 Waste Characterization Summary

The waste characterizations presented above indicate that there are several T-1 waste streams that meet LDRs and may be directly land disposed. These include the DU ingot (LLW), LDR-compliant soils (LLW/RCRA/TSCA), excavated debris (LLW/RCRA/TSCA), and project-generated debris (LLW).

In contrast, there are several T-1 waste streams that do not meet LDRs and must therefore be treated prior to land disposal. These include the DU, thorium, and historic sample waste streams (LLW/RCRA/TSCA); the cemented cyanide wastes (LLW/RCRA/ACM); non-LDR-compliant soils (LLW/RCRA/TSCA); and the decanted lathe coolant (LLW/RCRA/TSCA).

Sections 3 and 4 of this Report examine a number of offsite and onsite alternatives, respectively, for the treatment of the T-1 non-LDR-compliant waste streams.

3.0 IDENTIFICATION AND EVALUATION OF OFFSITE TREATMENT ALTERNATIVES

The waste characterization presented in the previous section of this Report identified several T-1 waste streams that do not meet LDRs and must be treated prior to land disposal. These waste streams include:

- DU, Thorium, and Historic Sample Wastes (LLW/RCRA/TSCA).

- Cemented Cyanide and Related Debris Wastes (LLW/RCRA/ACM).
- Non-LDR-Compliant Soils (LLW/RCRA/TSCA).
- Decanted Lathe Coolant (LLW/RCRA/TSCA).

The feasibility of treating the waste streams listed at an offsite facility is examined in this section. Specifically, treatment at three offsite DOE facilities and seven commercial facilities is considered. Identification and evaluation of these offsite treatment alternatives is presented below.

3.1 Offsite DOE Treatment Alternatives

The mixed waste treatment facilities currently operated within the DOE complex were evaluated with respect to the feasibility of treating T-1 non-LDR-compliant mixed wastes. The facilities considered include the TSCA Incinerator at Oak Ridge National Laboratory (ORNL), the M-Area Vitrification Plant at Savannah River Plant (SRP), and the Waste Experimental Reduction Facility (WERF) at the Idaho National Engineering Laboratory (INEL). Table 3-1 presents the regulatory permit and license status of these facilities as well as other information pertinent to the treatment of T-1 wastes.

The TSCA Incinerator at ORNL is not a viable option at this time because of a moratorium on the acceptance of out-of state wastes (other than from the DOE Portsmouth and Paducah facilities) imposed by the State of Tennessee. The time frame for the lifting of this moratorium is unknown. In addition, the processing capacity that is reserved at the facility for solid wastes is limited because of a large backlog of liquid wastes (preferred waste stream) to be treated at the facility. Under the facility's current Burn Plan, additional solid wastes are not expected to be considered for incineration until at least Fiscal Year 2000.

Table 3-1 indicates that the T-1 wastes radioactive metal and soil wastes do not meet the waste acceptance criteria of the M-Area Vitrification Plant because of the VOC levels present. The M-Area facility does not possess the necessary offgas treatment equipment to address the VOC levels in question. Table 3-1 also indicates that the WERF is not permitted to treat TSCA-regulated wastes.

A potential alternative to using one of the fixed DOE treatment facilities noted above is combining the T-1 wastes with a similar waste stream of another CERCLA project within the DOE Complex. Such a strategy may pose insurmountable regulatory and administrative challenges. Nonetheless, additional investigation of this strategy will be examined.

3.2 Offsite Commercial Treatment Alternatives

The possibility of treating the radioactive metal waste and contaminated soil at an offsite commercial facility was investigated. The search involved contacting numerous commercial facilities regarding their treatment capabilities and regulatory permit status; conferring with DOE Mixed Waste Focus Area personnel at INEL regarding commercially-available treatment capabilities; reviewing research regarding the identification of treatment alternatives for a nearly identical DU waste stream at the Hanford facility; and finally, publishing a Commerce Business Daily (CBD) announcement (Appendix B) requesting technical and regulatory permit and license information pertinent to the treatment of the T-1 radioactive metal, contaminated soil, and cemented cyanide wastes. The CBD announcement encouraged responses regarding both offsite and onsite treatment alternatives, but emphasized a preference that the wastes be treated at an existing offsite facility.

The search described above identified seven offsite commercial facilities: Materials and Energy Corporation (M&EC), Allied Technology Group (ATG) - Richland, Perma-Fix Environmental Services of Florida (Perma-Fix), Diversified Scientific Services, Inc. (DSSI), Starmet Corporation, Waste Control Specialists (WCS), and Envirocare of Utah, Inc. (Envirocare). The regulatory permit and license status of these facilities along with other information pertinent to the treatment of T-1 wastes is presented Table 3-2. This information is examined below first with respect to the treatment of the radioactive metal and soil wastes (i.e., low-level mixed waste including PCBs), and second, with respect to the treatment of the cemented cyanide waste (i.e., low-level mixed waste without PCBs).

3.2.1 Radioactive Metal and Soil Wastes

In order for an offsite facility to treat the T-1 radioactive metal and soil wastes, it must have the capability and permits to treat a mixed waste (LLW/RCRA/TSCA/CERCLA) as follows: all underlying hazardous constituents (both organic and inorganic) must be managed by either knowledge of the waste, or alternatively, treatment to LDRs required by 40 CFR 268. Knowledge of the wastes and analytical data indicate that a variety of chlorinated solvents, PCBs, and leachable cadmium must be reduced in their concentrations prior to landfill as a radioactive listed hazardous waste (F001, F002) meeting LDRs.

The information presented in Table 3-2 indicates that none of the six commercial facilities evaluated in the search for offsite alternatives are fully permitted and licensed at this time to treat the T-1 radioactive metal and soil wastes at this time. M&EC, for example, is not expected to have the requisite RCRA and TSCA permits in place for at least 12 months. In the case of ATG, managers expect their Richland facility to receive its RCRA/TSCA permit in 1999, however, permit-required demonstration testing of equipment that is to be installed in 1999 is not anticipated to be completed until the first quarter of Calendar Year 2000. Also, ATG's radioactive materials license limits the facility to receive only 10,000 kg of Atomic Energy Commission (AEC) source material. Although this constraint is exceeded by the approximately 30,000 kg of DU excavated from Trench 1, the company indicates that amendments to its radioactive materials license to exceed the source material limit on a project-by-project basis may be obtained within reasonable time frames (e.g., two to three months)."

Table 3-2 indicates that Perma-Fix is currently permitted under RCRA to store, blend, and repackage hazardous wastes. Perma-fix cannot currently treat hazardous waste. However, the company has applied for a modification to its RCRA Part B permit requesting approval to treat hazardous wastes as well. Approval is expected by the company in May 1999. The application is currently focused on a limited number of hazardous waste codes and hazardous constituents; Perma-Fix lacks test data describing performance of its proprietary in-house technology for all RCRA underlying hazardous constituents. Perma-fix has likewise submitted an application for the storage of TSCA wastes and anticipates regulatory approval for this request by mid 1999. The company has not yet submitted an application for the treatment of TSCA wastes, however. The company has recently applied for a TSCA RD&D permit for the experimental testing of PCB wastes. Data generated from the TSCA R&D permit will be used to support modification of the RCRA permit and preparation of a TSCA permit application. Although the TSCA RD&D permit does not impose a waste volume or mass limit, the proposed permit's stipulation

that wastes treated under this permit must be disposed at pretreatment levels effectively eliminates its use for treating the radioactive metal and soil waste streams.

WCS currently holds a RCRA permit that allows solidification/stabilization and chemical oxidation of hazardous waste. The company has applied for a permit modification to allow treatment with other processes, such as thermal desorption and dechlorination, which are necessary for the treatment of the T-1 radioactive metal and soil wastes. The estimated time for review and approval of this permit modification is 12 to 18 months. WCS is permitted at this time, however, to store the radioactive metal and soil wastes at their Andrews, Texas facility.

DSSI operates a fully permitted and licensed industrial boiler for the treatment of low level mixed waste *liquids* including aqueous liquids, organic solvents and used oils. The company has recently applied for a permit modification for the treatment of solid wastes. Approval of this request is not expected for at least 12 months. DSSI's radioactive materials license allows for the treatment of wastes containing radioactive materials with atomic numbers 1 through 83, and transuranics (including various isotopes) with atomic numbers 88, 90, and 92 through 96 and with an annual processing limit of over 20,000 curies. DSSI does not possess a TSCA permit, however, and liquid wastes processed at their industrial boiler facility must therefore contain less than 50 ppm PCBs.

Envirocare possesses the permits to handle both LLW and RCRA wastes. However, Envirocare lacks the necessary permit (and process equipment) for treating the TSCA-regulated Trench 1 radioactive metal and soil wastes. As noted in the introduction to this section, Starmet does not possess a RCRA or TSCA permit and the company does not currently have plans to apply for these permits."

3.2.2 Cemented Cyanide Waste

In order for an offsite facility to treat the T-1 cemented cyanide wastes, it must have the capability and permits to treat a LLW/RCRA/CERCLA mixed waste as follows: the specific hazardous constituents underlying the F006 and F008 waste codes must be treated to meet the 40 CFR 268 LDR standards. In particular, leachable cadmium and total cyanide must be reduced to LDRs prior to landfill. The treatment must be capable of handling TSCA ACM. The residues can then be land disposed as low-level radioactive, ACM, F006/F008 listed hazardous wastes meeting LDRs.

As is the case for the radioactive metal and soil wastes, none of the seven offsite facilities listed in Table 3-2 are fully permitted and licensed to treat the cemented cyanide wastes at this time. However, the information presented in Table 3-2 indicates that Perma-Fix and WCS may become fully permitted in this regard in approximately three to four months.

Perma-Fix must gain approval of their RCRA permit modification request to treat hazardous waste. As noted above, approval of this request is expected by May 1999. In lieu of the permit modification, Perma-Fix may treat the cemented cyanide waste at this time under the RCRA Treatability Exclusion. Review of the regulations pertaining to the Treatability Exclusion (40 CFR 261 and 40 CFR 268), as well as information obtained through the USEPA Hotline, indicate that successful treatment of the T-1 cyanide wastes under the Treatability Exclusion (i.e., LDRs are achieved for both cadmium and total cyanide) would allow land disposal of the treated wastes at a RCRA-regulated Subtitle C facility without further treatment in a RCRA-regulated or specifically exempted Treatment Unit.

It should also be noted that Perma-Fix has been issued CERCLA Offsite Authorization by the EPA as indicated in Table 3-2.

It is anticipated that WCS may also be fully permitted to treat the cemented cyanide waste in approximately three months. Although the company currently possesses a RCRA permit for chemical oxidation and stabilization/solidification (Table 3-2), their radioactive materials license must be amended to allow treatment of radioactive-contaminated wastes with these processes. This amendment has been submitted and is expected to be approved within two to three months. The State of Texas requires that this amendment be approved for treatability work as well. It should be noted that WCS has not yet been approved by RFETS to receive wastes. Kaiser-Hill conducted an audit of the WCS facility in February 1999 and an assessment of the findings is pending.

The technologies proposed by Perma-Fix and WCS to treat the cyanide wastes are similar and involve the use of chemical oxidation to reduce total cyanide levels below 590 mg/kg followed by cementation to stabilize the cadmium. Both companies indicate the need to conduct treatability tests with samples of the cemented cyanide waste in order to formulate the proper oxidation and stabilization "recipes." Treatability testing is particularly important considering the strong cyanide complexes that appear to exist in the waste suggested by the relatively low amenable (i.e., reactive) cyanide analytical data. Also, TCLP values approximately 10,000 times the LDR limit for cadmium (see Section 2) pose a challenge for treatment and warrant treatability testing as well.

Table 3-2 indicates that M&EC, ATG, DSSI, Starmet, and Envirocare could also employ the RCRA Treatability Exclusion to process the cemented cyanide waste. However, M&EC, DSSI, and Envirocare do not currently possess the necessary process equipment and ATG has expressed a preference not to conduct work under the Treatability Exclusion while their RCRA/TSCA permit application is being reviewed by the regulatory agencies. Starmet's business involves the recycling of DU and the fabrication of metal components. The firm is not interested in processing the cemented cyanide wastes.

4.0 ONSITE TREATMENT OF RADIOACTIVE METAL WASTES AND CONTAMINATED SOIL

The analysis presented in the previous section indicates that it may be one to two years before the T-1 radioactive metal and soil wastes can be treated at an offsite commercial facility. This lead time, as well as the uncertainty associated with it, necessitates an examination of onsite treatment alternatives. Per CERCLA, implementation of onsite treatment is not subject to the rather lengthy RCRA and TSCA permitting processes. The discussion presented in this section therefore considers alternatives for the onsite treatment of the radioactive metal and soil wastes. Onsite treatment of the cemented cyanide waste is not considered because a pathway for offsite treatment of these wastes is likely to exist in the next several months as discussed in Section 3 (i.e., Perma-Fix or WCS).

The search for different options to treat T-1 wastes identified six onsite treatment alternatives. The vendors offering an onsite treatment alternative along with the treatment technologies included in the alternatives are summarized below.

Respondent	Technologies included in Onsite Treatment Alternative
GTS Duratek	Steam Reforming, Solvated Electron Dechlorination Technology, and Stabilization.
Materials and Energy Corporation	Solvent Extraction/Direct Chemical Oxidation, Thermal Desorption, and Stabilization.
Geosafe Corporation	Batch Vitrification.
ATG	Continuous Plasma Arc Vitrification.
Perma-Fix	Thermal Desorption, Direct Chemical Oxidation, and Stabilization.
Starmet	Solvated Electron Dechlorination Technology, and Thermal Oxidation

Detailed descriptions and evaluations of each of these onsite treatment alternatives are presented in Appendix C. The evaluations focus on the expected effectiveness in achieving regulatory-driven treatment goals as well as the challenges associated with implementing the alternative at RFETS. Brief summaries of the treatment alternative evaluations are presented below.

4.1 GTS Duratek

GTS Duratek proposes that the radioactive metal and soil wastes be treated with a combination of solvated electron technology (SET) and steam reforming technology as illustrated by the process flowsheet presented in Figure 1. Following treatment by these processes, the wastes are then stabilized by cementation to eliminate the toxicity characteristic associated with the leachability of cadmium. SET technology employs a liquid reagent to dechlorinate the organic solvents and PCBs present in the wastes, rendering them as non-hazardous hydrocarbons. The chlorine present in the organic contaminants is displaced by hydrogen and forms either sodium or calcium chloride depending on the reagent used. Steam reforming technology volatilizes organic contaminants (i.e., chlorinated solvents and PCBs) from the solid waste matrix and destroys them by reaction with superheated steam. Because the degradation reactions occur in an oxygen-depleted environment (i.e., steam displaces air in the unit), the organics are reduced to simple gases without the problems associated with thermal oxidation (i.e., incineration). Steam reforming technology has the added benefit of eliminating the pyrophoric characteristic of the DU. Metallic uranium is irreversibly converted into uranium oxide (Waber, 1956).

Both steam reforming (Gibson, 1997) and SET (Commodore, 1998) have been found to be effective in reducing the concentrations of chlorinated solvents and PCBs required to meet LDRs. The crushing and screening operations performed prior to treatment (Figure 1) aid treatment by increasing the solid waste surface area available for contact with the reagent (i.e., SET solution or superheated steam). Such feed preparation activities have three important disadvantages: worker exposure, equipment shutdown, and equipment decontamination. The potential for exposing workers to contamination is significant considering the need to transfer the wastes from the drums to the feedstock preparation equipment and

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from treatment unit to treatment unit.
Even with the feed preparation operations described in Figure 1, it remains uncertain that the degree of solid-reagent contact necessary for effective treatment will be achieved in the SET unit when processing oily DU sludges and thorium pastes. "Channeling" may occur in these wastes which will serve to limit the surface area of the solid waste exposed to the liquid reagent. With respect to steam reforming, the need to remove the wastes from the container and size reduce them may or may not be necessary. Entire drums of waste have been successfully treated by steam reforming without first having to remove and prepare the waste. In these cases, the superheated steam effectively penetrated the solid wastes to desorb the organic contaminants. The degree of steam penetration depends on the physical and chemical nature of the waste and can only be verified through waste-specific treatability testing.

The reader is referred to Appendix C for a more in depth discussion of the materials handling issues associated with the treatment alternative suggested by GTS Duratek.

4.2 Materials & Energy Corporation (M&EC)

M&EC suggests that the radioactive metal and soil wastes be treated by solvent washing and vacuum-enhanced thermal desorption (TD), as illustrated by the flowsheet presented in Figure 2. As in the GTS Duratek process, the mineral oil is drained and the wastes segregated prior to treatment. Waste liquids and sludge recovered during oil draining, solvent washing, and TD operations are treated by direct chemical oxidation (DCO), and the waste from the DCO unit is stabilized for land disposal. Containers are decontaminated with a non-hazardous solvent and the spent solvent is recycled to the solvent washing unit.

The primary advantages of solvent washing are its simplicity, room temperature operation, and relatively high contaminant removal efficiencies for certain types of wastes such as granular solids and sands containing organic surface contamination. The effectiveness of solvent washing the T-1 oily sludges and pastes is uncertain, however. Particle size and porosity of the waste solids as well as any surface coatings and channeling may limit the solid-liquid contact achieved in the unit. The treatment approach suggested by M&EC addresses the need for solid-reagent contact (as well as solid-gas sweep contact in the TD unit) by sorting and size reducing the wastes prior to treatment. These feedstock preparation activities should enhance the overall waste-reagent contact achieved in both the solvent washer and the TD unit, but as discussed in Section 4.1 for the GTS Duratek alternative, such feed preparation generate worker exposure, equipment shutdown, and equipment decontamination concerns. Entrainment of solids during solid-liquid separation, safety hazards associated with using solvents with pyrophoric material, and the generation of secondary waste streams (i.e., spent solvent and filter media) pose operational challenges with this technology as well.

There is an abundance of data demonstrating the performance of TD technology for removing chlorinated solvents. In fact, the TD unit proposed by M&EC has been successfully used three times at RFETS for desorbing TCE and PCE from soils (i.e., Ryan's Pit, Mound Site, and the Trench T-3/T-4 projects). TD technology has also been shown to be effective in the removal of heavier organic contaminants such as PCBs (i.e., less than 2 ppm) when high vacuums are applied (Mclaren Hart, 1998). The pyrophoric nature of DU and the presence of PCBs in the wastes necessitates the use of an inert gas sweep, however. The presence of oxygen and PCBs at elevated temperatures may potentially result in the formation of dioxin and furan compounds. Treatability testing must be conducted to ensure that these reactions do not occur. Also, oils not removed in the solvent washer are susceptible to smoking,

where the nature of the radiant heat source can lead to high localized waste temperatures and subsequent cracking of any oils present.

4.3 Geosafe Corporation

Geosafe Corporation proposes that the T-1 radioactive metal and soil wastes be treated in a batch vitrification unit. The primary components of the unit are illustrated in Figure 3 and include a waste treatment cell, an offgas collection hood, and an offgas treatment system. The bottom of the cell is "lined" with approximately three feet of compacted, clean soil. Drums and waste boxes containing the radioactive metal and soil wastes are placed on the soil liner in the center of the treatment cell. Soil is then used to fill the void spaces inside and between the containers. Clean soil is then placed around and over the top of the drums and compacted with a backhoe or excavator.

With the offgas treatment system is in place, electrical current is applied to the contents of the treatment cell. The current is converted to heat which melts the soil and wastes from top to bottom. The temperature of the melt typically ranges from 1,600 to 2,000°C. The temperatures achieved in the melt serve to pyrolize organic contaminants and debris present in the soils and wastes to simple gases (e.g., carbon dioxide, carbon monoxide, simple hydrocarbons, water vapor, and hydrochloric acid). The offgas leaving the collection hood is treated prior to atmospheric discharge. Inorganic contaminants are oxidized and are chemically incorporated in the melt. After all wastes are melted, as indicated by the electrodes reaching the soil liner, the power is de-energized and the melt allowed to cool and solidify (several days). The resulting glass-like product is chipped out of the treatment cell and containerized for subsequent disposal. The treatment cell is charged with the next batch and the process repeated.

The batch vitrification process proposed by Geosafe has several important advantages with respect to the treatment of T-1 radioactive metal and soil wastes. First and foremost is the minimal amount of feed preparation and worker handling that is required. The process does not require that wastes be removed from their containers. The steel drums and waste boxes are melted along with the wastes in the treatment cell. The reader is referred to Appendix C for a detailed discussion regarding specific activities associated with loading the treatment cell.

As is the case with steam reforming and SET, vitrification has the benefit of eliminating regulated organic contaminants in one step. In addition, vitrification has the benefit of stabilizing radionuclides and hazardous metals in this same step. The need to transfer the wastes to a cementation unit, for example, is eliminated. Stabilization is achieved by chemically incorporating the metals into the glass product. Additional information concerning melt chemistry and the incorporation of inorganic contaminants in the melt is presented in Appendix C.

Bench-scale vitrification data indicate that as much as 99.99% of the uranium present in the feedstock wastes is retained in the final glass product (Hansen, 1991). Similar studies have indicated retention efficiencies as high as 99.99% for thorium as well (Hansen, 1991). Unfortunately, bench- and pilot-scale studies suggest only a 67 to 75% retention efficiency for cadmium, a semi-volatile metal. A commonly cited drawback of vitrification technology is the potential for hot gases generated in the melt to accumulate in void spaces present within the treatment cell. If the space is large enough and sufficiently confined, violent release of accumulated vapor can occur in the melt. This phenomenon is of particular concern when attempting in place or *in situ* vitrification of buried wastes (i.e. In this case, it is difficult to know where void spaces may exist in the subsurface or within buried containers. In contrast, there is

much more control and certainty in batch or *ex situ* applications of this technology. Void spaces can be filled and compacted while charging the treatment cell.

Appendix C provides additional discussion on the advantages and disadvantages associated with batch vitrification of T-1 wastes.

4.4 Allied Technology Group (ATG)

ATG proposes that the T-1 radioactive metal and soil wastes be treated in a continuous vitrification unit. As illustrated in Figure 4, electric power is delivered to the treatment unit in two forms. The first is an alternating current, similar to that employed in the Geosafe batch vitrification process, that is applied to the melt at the bottom of the unit. A second source of power, a high energy direct current, is applied in the vapor space directly over the surface of the melt. The resulting electric arc creates an extremely high temperature plasma (approximately 12,000°C).

In practice, waste is continuously fed into the treatment chamber with an auger. The feed is directed through the plasma and into the melt. Pyrolysis of organic contaminants occurs in both the melt and the plasma arc. The elevated temperatures of the plasma ensure that the pyrolytic reactions are taken to completion to form carbon dioxide and hydrogen. The offgas from the plasma arc unit is treated prior to atmospheric discharge in a similar manner as described earlier for the batch vitrification process. The melt continuously exits the treatment unit through an overflow weir. The molten flow is directed into waste containers where it is allowed to cool and solidify.

Many of the same assessments made in Section 4.3 for batch vitrification technology also apply to ATG's continuous plasma arc vitrification process. Both technologies offer the benefit of organic contaminant destruction and inorganic contaminant immobilization in one processing step. However, the continuous feed and processing requirements of the plasma arc process necessitates size reduction and blending of the wastes to ensure a successful operation. Such activities raise concerns of worker exposure and equipment downtime as discussed in other sections of this report regarding the technologies proposed by GTS Duratek, M&EC, and Perma-Fix. The ability to decontaminate the feed preparation equipment and feed auger for free release at the conclusion of the project is also uncertain. The risks associated with auger jamming and flow blockage must also be considered.

A more detailed evaluation of ATG's continuous plasma arc treatment technology is provided in Appendix C.

4.5 Perma-Fix Environmental Services

As with M&EC, Perma-Fix suggests that solvent washing and TD technologies be used to remove organic contaminants from the T-1 radioactive metal and soil wastes (Figure 5). Likewise, cementation is proposed to solidify wastes prior to disposal. Description and evaluation of these technologies for the treatment of T-1 wastes need not be repeated. The reader is referred to the discussion and analysis presented in Section 4.2 and Appendix C.

4.6 Starmet Corporation

Starmet proposes that the Trench 1 radioactive metal wastes be segregated into four groups and each

group treated as follows:

Group	Waste Classification	Proposed Treatment Strategy
1	LLW	Treatment at Starmet's DU processing facility in South Carolina.
2	LLW/TSCA	Onsite treatment by SET followed by treatment at Starmet.
3	LLW/RCRA	Treatment at Perma-Fix in Gainesville, Florida.
4	LLW/RCRA/TSCA	Onsite treatment by SET followed by treatment at Perma-Fix.

Except for the DU ingot, all Trench 1 radioactive metal wastes are LLW/RCRA/TSCA and fall into Starmet's Group 4. The DU ingot is LLW and falls into Group 1. The choice to dispose of the DU ingot at NTS rather than have it processed at Starmet is based on economics. Likewise, the combination of onsite and offsite treatment proposed by Starmet for all other Trench 1 wastes is not economical. It makes far more sense to continue treatment through to its logical end once it is started as opposed to repackaging SET-treated DU wastes with fresh mineral oil and shipping to an offsite location to complete treatment. Also, there are several disadvantages with using SET to treat the Trench 1 radioactive metal wastes as described in Section 4.1. These include significant materials handling and worker exposure, the potential absence of adequate solid-liquid contact in an oily or pasty sludge (i.e., channeling), and equipment decontamination. Finally, as discussed in Section 3.2, Perma-Fix is not fully permitted to treat LLW/RCRA/TSCA waste at this time. Such a strategy would necessarily involve interim storage of the wastes for one to two or more years prior to treatment. The permit status of Perma-Fix was discussed earlier in Section 3.2.1.

4.7 Preferred Onsite Treatment Alternatives

A comparative analysis of the onsite treatment alternative evaluations (Appendix C) suggest that two technologies, steam reforming and batch vitrification, have the most potential for successfully treating the T-1 radioactive metal and soil wastes. In summary, the distinguishing benefits of these technologies include minimal feed preparation and worker exposure and the destruction of organic contaminants in one processing step. Batch vitrification has the added advantage of immobilizing the inorganic contaminants into a superior waste form in this same processing step. However, there are uncertainties associated with the application of each of these treatment technologies to the T-1 wastes. In the case of steam reforming, for example, there is uncertainty regarding the ability of the steam to effectively penetrate the various solid waste forms without first size reducing and segregating the feedstock. Uncertainties regarding batch vitrification include hazards associated with void spaces present in the wastes, vaporization of semi-volatile metals, and formation of dioxin and furan compounds resulting from the partial oxidation of PCBs in the feedstock.

Using batch vitrification as a proxy, the implementation of an onsite treatment alternative is estimated to cost approximately two million dollars and require approximately 15 to 18 months to complete (see Appendix C).

5.0 PROPOSED WASTE STREAM DISPOSITION

This section presents the proposed disposition pathways for each of the waste streams generated by the T-1 Source Removal project. The disposition pathways proposed are based on the waste characterizations and evaluations of offsite and onsite treatment alternatives presented in this Report.

Tables 5-1 through 5-4 summarize the proposed disposition of each T-1 waste stream. The discussion that follows addresses the waste streams by common disposition pathway (i.e., direct land disposal vs. treatment).

5.1 DU Ingot, Debris, and LDR-Compliant Soils

Many of the T-1 waste streams meet LDRs and will be land disposed at either NTS or Envirocare. The wastes that will be sent to NTS include the DU ingot (one drum, Table 5-1) and the project-generated debris (six B-88 and four B-12 waste boxes, Table 5-4). The project-generated debris includes general project-related debris and spent PPE. Waste streams that will be sent to Envirocare include soils that are contaminated below LDR levels (52 B-88 waste boxes, Table 5-3) and debris excavated from T-1 (five B-88 waste boxes, Table 5-4).

As discussed in Section 2 of this Report, the excavated debris waste stream is LDR-compliant and can legally be disposed at Envirocare. However, because of the elevated level of PCBs detected in the "ice cream cartons" (i.e., 730 ppm) present in this waste stream, Envirocare may decline to accept it. If this proves to be the case, the debris waste stream will be treated along with the radioactive metal wastes and soils contaminated above LDR levels. Alternatively, segregation of the cartons from the excavated debris waste may be considered in the event that Envirocare does not accept the waste stream as it is currently containerized. The incremental costs associated with storage and treatment of the excavated debris as it is currently containerized will be compared with the costs associated with segregation and resampling. The most economic solution will be pursued.

5.2 Decanted Lathe Coolant

Table 5-4 indicates that two of the three drums of decanted lathe coolant will be treated onsite at the CWTF located in Building 891. These two drums have already been transferred to the CWTF and are awaiting treatment. Because the concentration of Aroclor-1254 detected in the aqueous and organic liquids in the third drum exceed the CWTF waste acceptance criteria for this contaminant, the third drum will be treated along with the radioactive metal and soil wastes (see below).

5.3 Non-LDR-Compliant Wastes

Six T-1 waste streams exceed LDR levels and must be treated. These include the DU waste (130 overpack drums and twenty-four B-12 waste boxes, Table 5-1), the thorium waste (one overpack drum and one B-12 waste box, Table 5-1), the "historic sample waste" (one B-12 waste box, Table 5-1), the non-LDR-compliant soil (eleven B-88 waste boxes, Table 5-3), and the cemented cyanide waste and related debris (11 drums, Table 5-2).

The evaluation of offsite treatment alternatives presented in Section 3 indicates there are no facilities that

are currently able to treat any of these five waste streams at this time. One offsite treatment facility within the DOE Complex, the TSCA Incinerator at ORNL, is able to treat the wastes from a technical and regulatory standpoint. However, a moratorium by the State of Tennessee regarding the acceptance of out-of-state wastes at this facility is currently in place. The time frame for the lifting of this moratorium is unknown. In addition, seven offsite commercial facilities were identified and evaluated in this Report. Unfortunately, none of the seven facilities currently possess all of the necessary permits and licenses to treat the radioactive metal, cemented cyanide, or soil waste streams at this time.

5.3.1 Cemented Cyanide Waste

Two facilities, Perma-Fix and WCS, appear to be less than six months away from obtaining the required permits and license modifications necessary to treat the T-1 cemented cyanide wastes. All seven of the commercial facilities identified in this Report could treat the cemented cyanide wastes under the RCRA Treatability Exemption. A thorough evaluation will be completed to determine the best offsite facility to receive and treat the cemented cyanide waste. Barring any unforeseen circumstances, the T-1 cemented cyanide waste and related debris should be shipped to an offsite facility for treatment prior to the end of Fiscal Year 1999.

5.3.2 Radioactive Metal and Soil Waste

As noted above, no offsite facilities possess all of the necessary permits and licenses to treat the T-1 radioactive metal and soil wastes at this time. Four of the commercial facilities identified are currently working toward obtaining the permits and licenses necessary to treat these waste streams: M&EC, ATG-Richland, Perma-Fix, and WCS. All four of these facilities appear to be approximately 12 to 24 months away from being authorized to treat LLW/RCRA/TSCA mixed wastes.

Although offsite treatment cannot be conducted at this time, the four commercial facilities noted above are presently permitted or should be permitted this fiscal year for the storage of the T-1 radioactive metal and soil waste streams. Storage of the T-1 wastes at a facility that is awaiting regulatory approval for the treatment of these wastes would provide for safe, interim storage at an indoor facility prior to treatment at that location. The radioactive metal and soil wastes are presently being stored outdoors at the T-1 project site on an interim basis in a compliant manner. Indoor storage at an offsite facility is preferred to storage at the T-1 project site or indoor storage at RFETS. Offsite interim storage is consistent with making progress toward site closure and will eliminate onsite inspection and maintenance costs.

Onsite treatment of the radioactive metal wastes and contaminated soil has been eliminated from consideration. Although batch vitrification and steam reforming may be technically feasible, there are a number of issues associated with their implementation at RFETS. Because both are thermal processes, a variety of air emission issues exist with Clean Air Act requirements as well as negative public perception and safety concerns regarding the operation of thermal units at RFETS. Also, treatability testing is necessary prior to making an affirmative project-specific determination with respect to the effectiveness of treatment. Finally, it is estimated that implementation of an onsite treatment project would require approximately 18 months to complete.

Safe interim storage and future treatment and disposal at an approved and permitted offsite commercial facility is the best path forward at this time for the radioactive metal and soil waste streams. A

contractual arrangement with a commercial facility for storage and future treatment and disposal of the wastes will be pursued this fiscal year. In the event that the pursuit of the proposed strategy of offsite shipment and future treatment proves to not be viable, investigation of longer term storage of T-1 wastes at RFETS will be investigated.

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TABLES

Table 2-1

Waste Stream Characterization - Radioactive Metals

Waste Stream	Regulatory Classifications	Number of Containers	Container Type	Volume/Weight
Depleted Uranium	CERCLA Waste, LLW, Hazardous Waste (F001, F002, D006), PCB Remediation Waste.	76 48 5 1 24	55-Gallon OP 83-Gallon OP 85-Gallon OP 110-Gallon OP B12	65.5 yd^3/155,560 lbs
DU - Ingot ("Puck")	CERCLA Waste, LLW.	1	83-Gallon OP	<0.5 ft^3/163 lbs
Thorium waste	CERCLA Waste, LLW, Hazardous Waste (F001, F002, D006), PCB Remediation Waste.	1 1	83-Gallon OP B-12	1.87 yd^3/5,587 lbs
Historic Samples (i.e., natural uranium and "tuballoy")	CERCLA Waste, LLW, Hazardous Waste (F001, F002, D006), PCB Remediation Waste.	1	B-12	1.6 yd^3/4,850 lbs

Table 2-2

Waste Stream Characterization - Cemented Cyanide

Waste Stream	Regulatory Classifications	Number of Containers	Container Type	Volume/ Weight
Cemented Cyanide	CERCLA Waste, LLW, Hazardous Waste (F006, F008, D006), TSCA-Asbestos Waste.	10	55-Gallon Drum	2.7 yd^3/6,294 lbs
Cemented Cyanide-Related Debris (i.e., drum lids, rings, sample equipment, and PPE used in cemented cyanide sampling and packaging tasks).	CERCLA Waste, LLW, Hazardous Waste (F006, F008, D006), TSCA-Asbestos Waste.	1	83-Gallon Drum	0.4 yd^3/81 lbs

Table 2-3

Waste Stream Characterization - Soil

Waste Stream	Regulatory Classifications	Number of Containers	Container Type	Volume/ Weight
Soil (5,000 ≤ cpm ≤10,000 and OVA < 25 ppm above background)	CERCLA Waste, LLW, Hazardous Waste (F001, F002), Bulk PCB Remediation Waste.	22	B-88	74.6 yd^3/195,444 lbs
Soil (cpm >10,000 and OVA < 25 ppm above background)	CERCLA Waste, LLW, Hazardous Waste (F001, F002), Bulk PCB Remediation Waste.	30	B-88	106.5 yd^3/280,282 lbs
Soil (OVA ≥ 25 ppm above background)	CERCLA Waste, LLW, Hazardous Waste (F001, F002), Bulk PCB Remediation Waste.	11	B-88	35.5 yd^3/91,444 lbs

cpm = counts per minute (i.e., radioactivity)
OVA = organic vapor analyzer
ppm = parts per million (i.e., organic vapor)

Table 2-4

Waste Stream Characterization - Lathe Coolant and Debris

Waste Stream	Regulatory Classifications	Number of Containers	Container Type	Volume/ Weight
Decanted Lathe Coolant (Aqueous Liquid)	CERCLA Waste, LLW, Hazardous Waste (F001, F002), PCB Remediation Waste.	2	55-Gallon Drum	110 gal
Decanted Lathe Coolant (Aqueous and Organic Liquids)	CERCLA Waste, LLW Hazardous Waste (F001, F002), PCB Remediation Waste.	1	55-Gallon Drum	<15 gal
Excavated Debris	CERCLA Waste, LLW, Hazardous Debris Waste (F001, F002), PCB Remediation Waste.	5	B-88	17.8 yd^3/16,214 lbs
Project-Generated Debris	CERCLA Waste, LLW.	1 3	B-88 B-12	8.4 yd^3/5,124 lbs
Project-Generated PPE	CERCLA Waste, LLW.	5 1	B-88 B-12	19.4 yd^3/7,934 lbs

Table 3-1
Permit and License Status of Offsite DOE Facilities and Projects

DOE Facility	RCRA Permit	TSCA Permit	Radioactive Materials License	T1 Wastes Meet WAC	Comments
TSCA Incinerator Oak Ridge, TN	Yes	Yes	Yes	Yes	Current moratorium on the acceptance of out-of-state wastes. Overbooked solids treatment capacity.
M-Area Vitrification Plant Savannah River, SC	Yes	No	Yes	No. VOC content too high. Metallic solids not accepted.	WAC limit for organic contaminants is very low. Facility does not include an off-gas treatment system for VOCs.
WERF Idaho Falls, ID	Yes	No	Yes	No. PCB's not accepted.	

Table 5-1

Proposed Waste Stream Disposition - Radioactive Metals

Waste Stream	Regulatory Classifications	Number of Containers	Container Type	Proposed Disposition
Depleted Uranium	CERCLA Waste, LLW, Hazardous Waste (F001, F002, D006), PCB Remediation Waste.	76 48 5 1 24	55-Gallon OP 83-Gallon OP 85-Gallon OP 110-Gallon OP B12	Offsite Storage and Treatment
DU - Ingot ("Puck")	CERCLA Waste, LLW.	1	83-Gallon OP	Land Disposal at NTS
Thorium waste	CERCLA Waste, LLW, Hazardous Waste (F001, F002, D006), PCB Remediation Waste.	1 1	83-Gallon OP B-12	Offsite Storage and Treatment
Historic Samples (i.e., natural uranium and "tuballoy")	CERCLA Waste, LLW, Hazardous Waste (F001, F002, D006), PCB Remediation Waste.	1	B-12	Offsite Storage and Treatment

Table 5-2

Proposed Waste Stream Disposition - Cemented Cyanide

Waste Stream	Regulatory Classifications	Number of Containers	Container Type	Proposed Disposition
Cemented Cyanide	CERCLA Waste, LLW, Hazardous Waste (F006, F008, D006), TSCA-Asbestos Waste.	10	55-Gallon Drum	Offsite Storage and Treatment
Cemented Cyanide-Related Debris (i.e., drum lids, rings, sample equipment, and PPE used in cemented cyanide sampling and packaging tasks).	CERCLA Waste, LLW, Hazardous Waste (F006, F008, D006), TSCA-Asbestos Waste.	1	83-Gallon Drum	Offsite Storage and Treatment

Table 5-3

Proposed Waste Stream Disposition - Soil

Waste Stream	Regulatory Classifications	Number of Containers	Container Type	Proposed Disposition
Soil (5,000 ≤ cpm ≤10,000 and OVA < 25 ppm above background)	CERCLA Waste, LLW, Hazardous Waste (F001, F002), Bulk PCB Remediation Waste.	22	B-88	Land Disposal at Envirocare
Soil (cpm >10,000 and OVA < 25 ppm above background)	CERCLA Waste, LLW, Hazardous Waste (F001, F002), Bulk PCB Remediation Waste.	30	B-88	Land Disposal at Envirocare
Soil (OVA ≥ 25 ppm above background)	CERCLA Waste, LLW, Hazardous Waste (F001, F002), Bulk PCB Remediation Waste.	11	B-88	Offsite Storage and Treatment

cpm = counts per minute (i.e., radioactivity)
OVA = organic vapor analyzer
ppm = parts per million (i.e., organic vapor)

Table 5-4

Proposed Waste Stream Disposition – Lathe Coolant and Debris

Waste Stream	Regulatory Classifications	Number of Containers	Container Type	Proposed Disposition
Decanted Lathe Coolant (Aqueous Liquid)	CERCLA Waste, LLW, Hazardous Waste (F001, F002), PCB Remediation Waste.	2	55-Gallon Drum	Treatment at CWTF (Building 891)
Decanted Lathe Coolant (Aqueous and Organic Liquids)	CERCLA Waste, LLW, Hazardous Waste (F001, F002), PCB Remediation Waste.	1	55-Gallon Drum	Offsite Storage and Treatment
Excavated Debris	CERCLA Waste LLW, Hazardous debris waste (F001, F002), PCB Remediation Waste.	5	B-88	Land Disposal at Envirocare (or Offsite Storage and Treatment).
Project-Generated Debris	CERCLA Waste, LLW.	1 3	B-88 B-12	Land Disposal at NTS
Project-Generated PPE	CERCLA Waste, LLW.	5 1	B-88 B-12	Land Disposal at NTS

FIGURES

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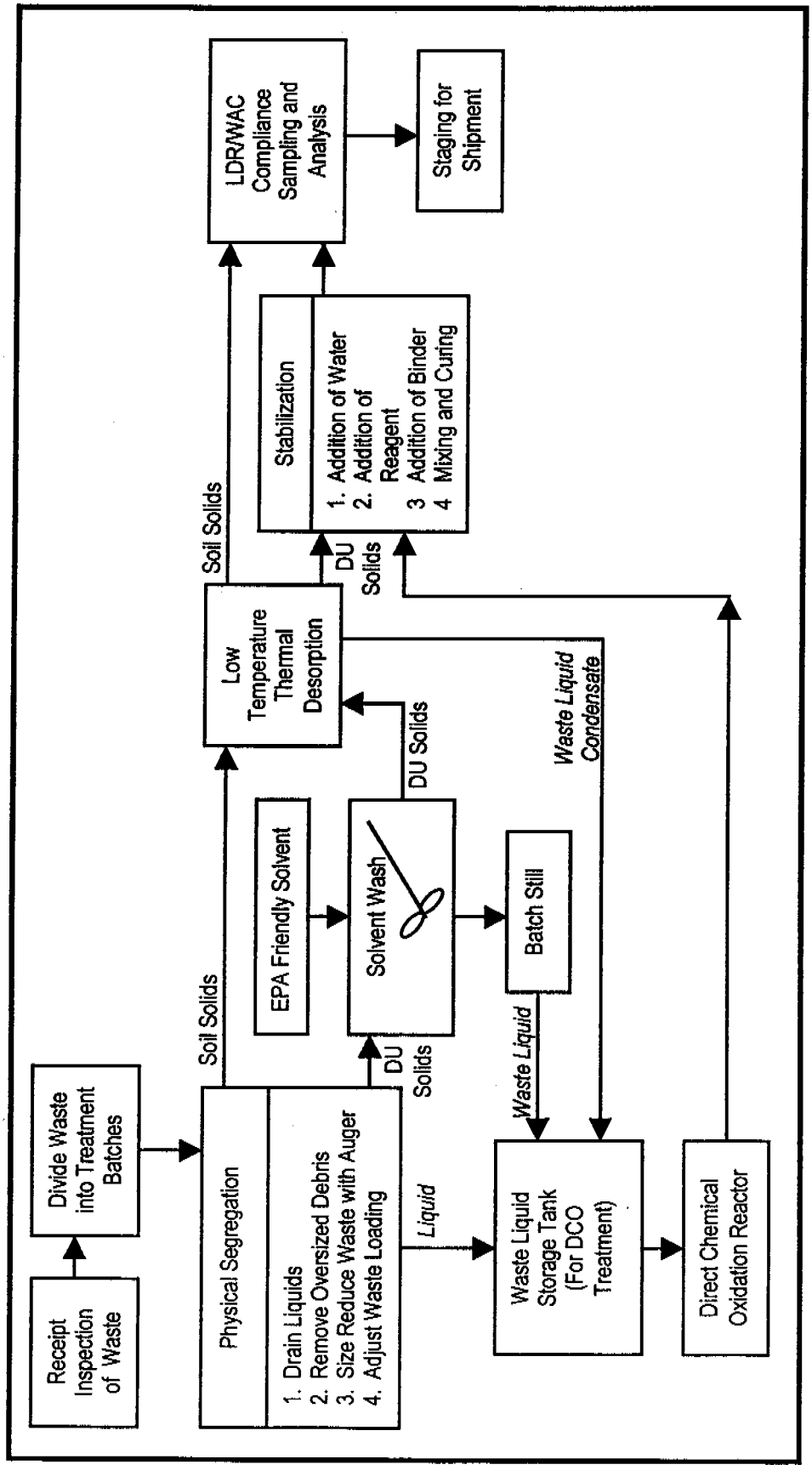

Figure 2 - Materials & Energy Corporation
Proposed Treatment Flowsheet For Depleted Uranium and Contaminated Soil

GEOMELTING

GeoMelt Stationary Batch System Schematic

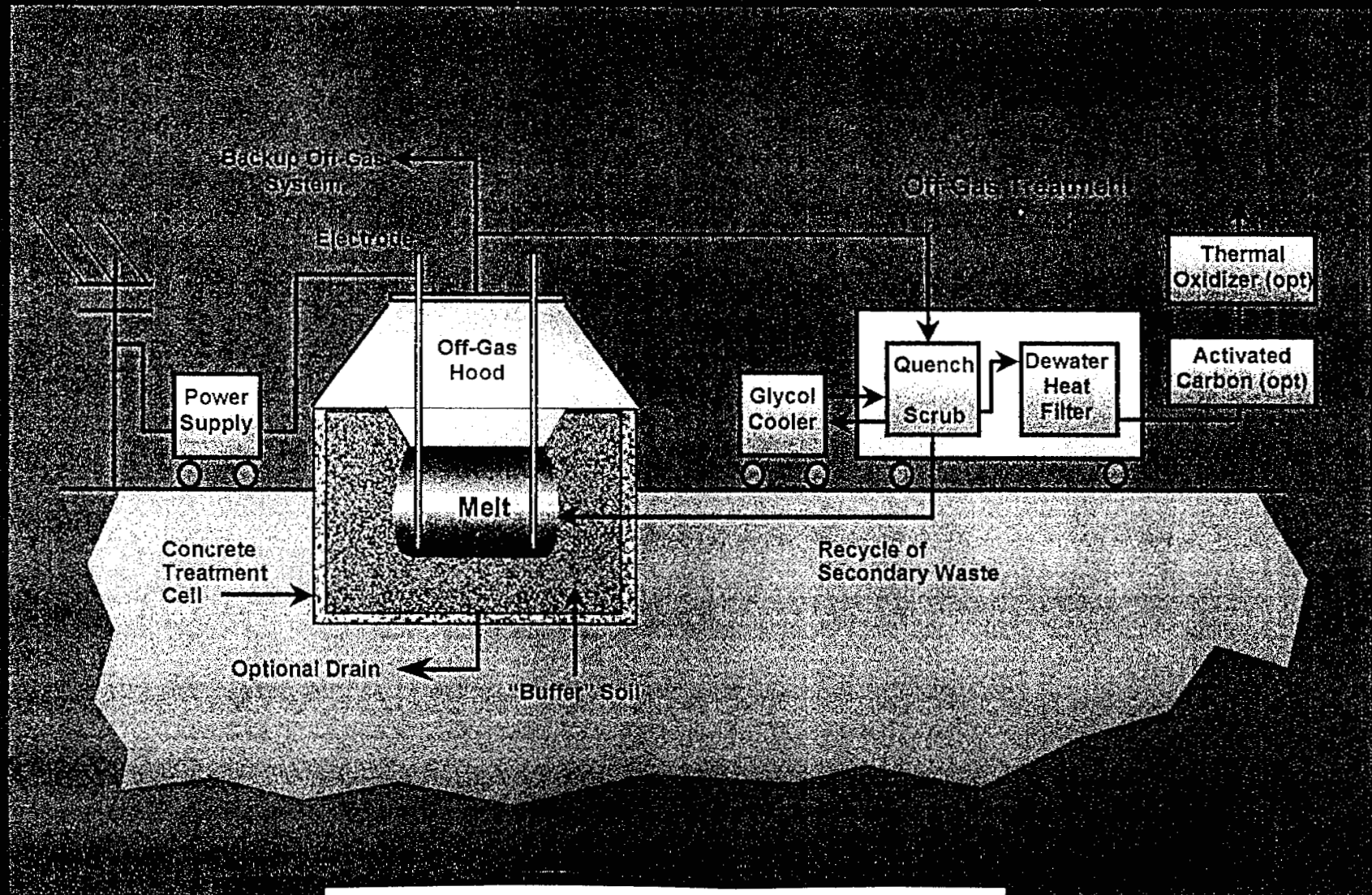

Figure 3 - Geosafe Batch Vitrification Flowsheet

Geosafe Corporation

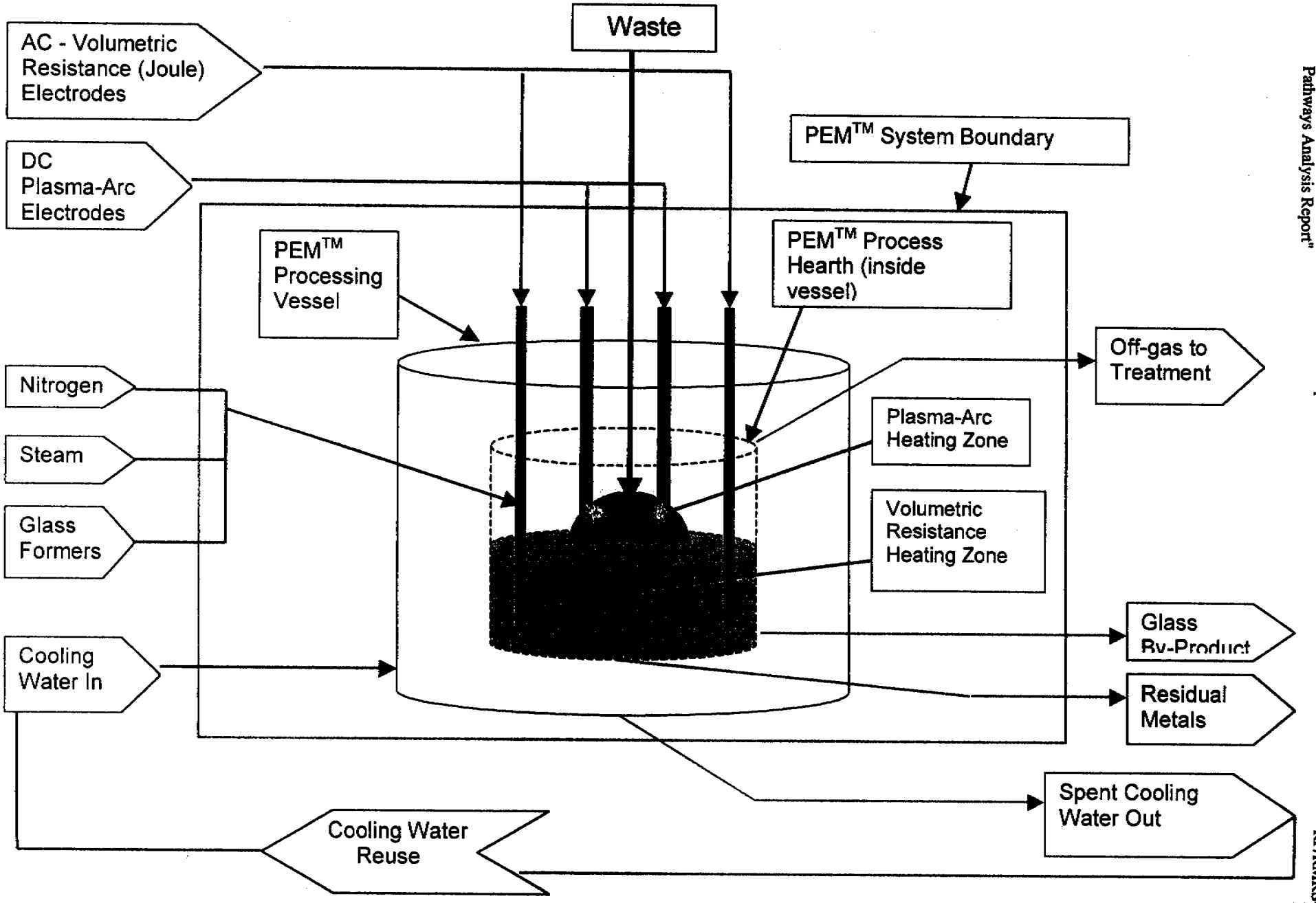

Figure 4 - ATG Plasma Arc Vitrification Unit

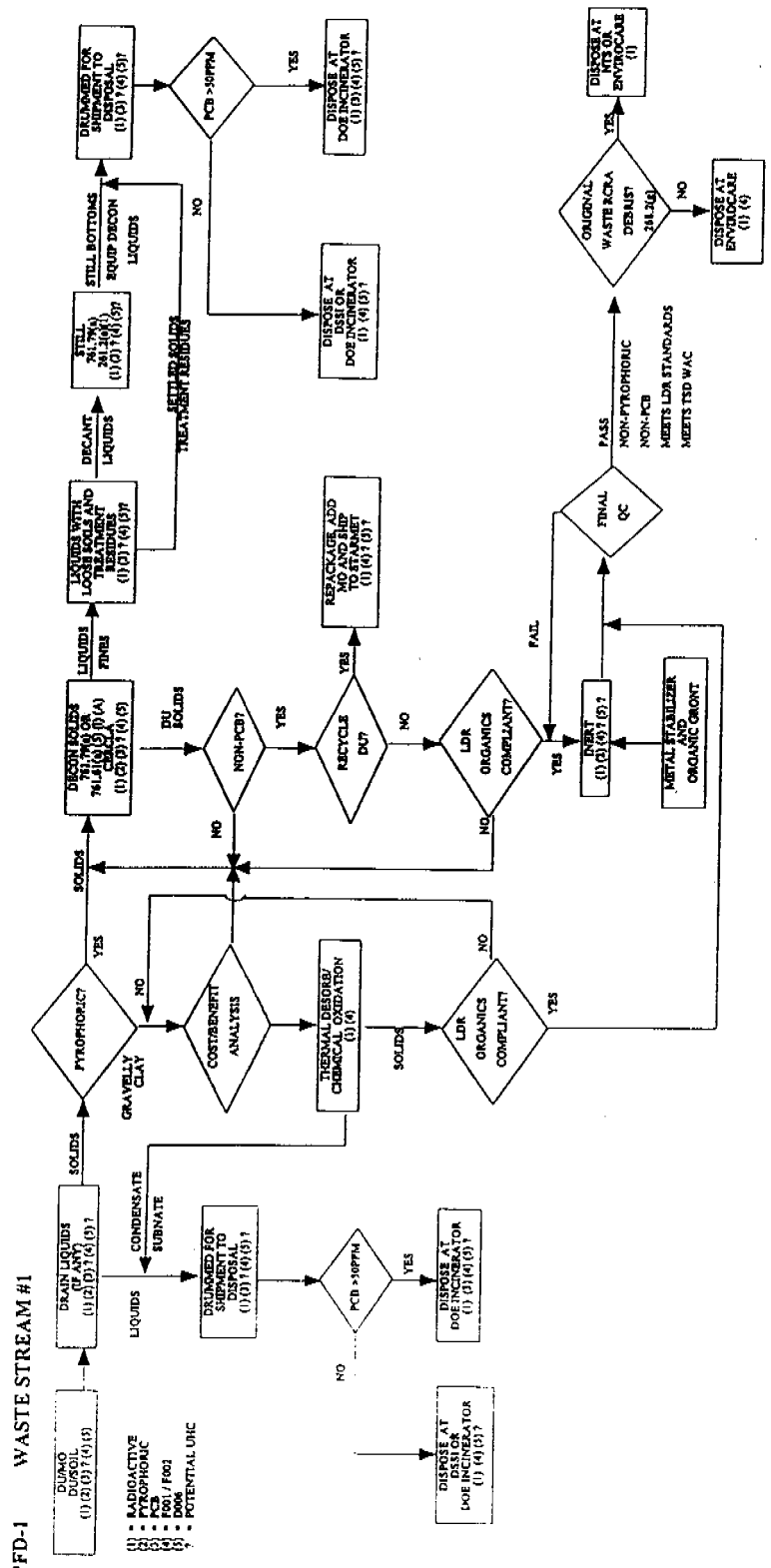

Figure 5
Perma-Fix Process Flowsheet

Appendix A

ANALYTICAL DATA

for the

TRENCH 1 SOURCE REMOVAL WASTE STREAMS

Table A-3
Analytical Data Summary - Soils

Soil: VOC > 25 ppm OVA

			All Radionuclides in pCi/g				All Chemicals in mg/kg			
RIN	Location	ContainerType	U-238	U-235	235/238	AM-241	PCE	TCE	PCB-1254	SVOC
98A2116-001	X09761	B-88	334.00	3.53	0.16	ND	0.84 B	0.045 J	0.97	low detections of few SVOCs
98A2116-002	X09752	B-88	1,300.00	7.36	0.09	ND	O.32	ND	1.1	low detections of few SVOCs
98A2116-003	X09758	B-88	708.00	4.23	0.09	ND	0.46	ND	2.5	low detections of few SVOCs
98A2116-004	X09746	B-88	796.00	14.00	0.27	ND	0.42	ND	1.8	low detections of few SVOCs
98A2116-005	X09755	B-88	245.00	0.00	0.00	ND	0.27	ND	0.19	low detections of few SVOCs
98A2116-006	X09756	B-88	1,470.00	18.50	0.20	ND	0.82	ND	1.6	low detections of few SVOCs
98A2116-007	X09745	B-88	466.00	4.53	0.15	ND	0.47	ND	1.3	low detections of few SVOCs
98A2116-008	X09743	B-88	92.40	0.00	0.00	ND	0.067 J	ND	0.45	low detections of few SVOCs
98A2116-009	X09743	B-88	148.10	2.45	0.26	ND	0.140 J	ND	9.5 D	low detections of few SVOCs
98A2116-010	X09744	B-88	3,980.00	45.10	0.18	ND	51 D	0.130 J	16 D	low detections of few SVOCs
98A2116-011	X09735	B-88	230.00	5.27	0.36	ND	0.63 B	ND	ND	Big TICS
98A2116-012	X09726	B-88	137.00	1.28	0.15	ND	0.73 B	ND	0.53	Big TICS

Table A-3 (cont)
Analytical Data Summary - Soils

SOIL > 10,000 CPM			Gamma Spectroscopy (pCi/g)			Radiochemcial (pCi/g)		Total VOCs (ug/kg)						Total SVOCs (ug/kg)	Total PCBs (ug/kg)	TCLP (mg/L)					Reactives (mg/kg)		
RIN	Location	ContainerType	U-238	U-235	235/236	AM-241	Pu-239	PCE	TCE	xylenes	acetone	methylene chloride	2-butanone		Aroclor-1254	VOCs	SVOCs	pesticides	herbicides	metals	Cyanide	Sulfide	pH
98A2114-001	X09759	B-88	670.00	3.91	0.09	0.13	1.39	24.00	6 U	6 U	4 JB	7 B	12 U	low SVOCs	850	0.048 mg/L PCE, 0.017 mg/L TCE J	non-detects	non-detects	non-detects	< TCLP	0.50 U	60.1	8.3
98A2114-003	X09741	B-88	1,250.00	8.51	0.08																		
98A2114-004	X09714	B-88	509.00	9.45	0.29																		
98A2114-005	X09737	B-88	306.00	1.90	0.10																		
98A2114-006	X09718	B-88	547.00	10.90	0.31	0.29	2.74	1.1U	1.1 U	2.2 U	7.8 B	3.30	2.0 JB	low TICs	not analyzed	carbon tetrachloride 0.0562*	non-detects	non-detects	non-detects	< TCLP	-0.0388 U	5.39 J	7.84
98A2114-008	X09718	B-88	70.50	1.85	0.41	0.53	0.14	1.2 U	1.2 U	2.0 J	10.1 B	4.00	2.3 JB	low TICs	not analyzed	carbon tetrachloride 0.0469*	non-detects	non-detects	non-detects	< TCLP	-0.0336 U	0.173 J	8.35

SOIL: 5,000 - 10,000 CPM			Gamma Spectroscopy (pCi/g)			Radiochemcial (pCi/g)		Total VOCs (ug/kg)						Total SVOCs (ug/kg)	Total PCBs (ug/kg)	TCLP (mg/L)					Reactives (mg/kg)		
RIN	Location	ContainerType	U-238	U-235	235/236	AM-241	Pu-239	PCE	TCE	xylenes	acetone	methylene chloride	2-butanone		Aroclor-1254	VOCs	SVOCs	pesticides	herbicides	metals	Cyanide	Sulfide	pH
98A2113-001	TR00696	stockpile	782.00	8.02	0.16																		
98A2113-002	TR01588	stockpile	600.06	4.80	0.12																		
98A2113-003	TR02098	stockpile	43.42	0.63	0.23																		
98A2113-004	TR02098	stockpile	31.59	0.82	0.30																		
98A2113-005	TR02098	stockpile	24.80	0.73	0.46																		
98A2113-006	X09722	B-88	170.00	2.36	0.22	0.31	1.03	1.1 U	1.1 U	2.2 U	9.9 B	0.98 J	5.8 U	low TICs	not analyzed	carbon tetrachloride 0.0417 J*	non-detects	non-detects	non-detects	< TCLP	-0.0264 U	0.472 J	8.04

B = detected in blank
U = detection limit
J = result below instrument detection limit, estimated value

*Note: In samples 98A2114-006, 008 and 98A2113-006, carbon tetrachloride was detected in the TCLP leachate. However, this compound was also detected in the corresponding TCLP blanks at approximately the same concentration and was not detected in the collocated samples analyzed for total VOCs. Therefore, this contaminant can only be considered a result of internal laboratory contamination, and is not reflective of the waste.

Appendix B

COMMERCE BUSINESS DAILY ANNOUNCEMENT

for the

TREATMENT OF TRENCH 1 SOURCE REMOVAL WASTES

CBD Announcement
Final 11/20/98

PART: U.S. GOVERNMENT PROCUREMENTS
SUBPART: SERVICES
CLASSCOD: C--Architect and Engineering Services - Construction--Potential Sources Sought
OFFADD: Rocky Mountain Remediation Services, L.L.C., Rocky Flats Environmental Technology Site, P.O. Box 464, Golden, Colorado 80402-0464
SUBJECT: C--TREATMENT AND DISPOSAL OF DEPLETED URANIUM, SOIL, AND CYANIDE WASTES
SOL RM-SS-01
DUE 121498
POC Technical: Robert Cygnarowicz (303) 966-7916 or Procurement: Karen Fairchild (303) 966-4726
DESC: The Closure Management Division of Rocky Mountain Remediation Services, L.L.C. (RMRS) is currently planning for the treatment and disposal of depleted uranium (DU), soil, and cemented cyanide wastes that were excavated during a CERCLA removal action from Trench 1 at the Rocky Flats Environmental Technology Site (RFETS). RFETS is located approximately 16 miles northwest of Denver, Colorado.

Waste Stream #1: The DU wastes (approximately 30 tons) range from hard/compacted solids to sludges and pastes and are classified as Atomic Energy Commission source material. U-238 activities in these wastes typically range from 150,000 to 340,000 pCi/g. Excavated drums of DU have been overpacked into 160 steel drums and 29 steel waste boxes (1.6 cubic yards each). Mineral oil has been added to the drummed waste to temporarily inert the potentially pyrophoric DU. Soil has been added to the boxed waste for the same purpose. The DU wastes are contaminated with F-listed chlorinated solvents, semi-volatile organic compounds, polychlorinated biphenyls (PCBs), and metals. The primary contaminants of concern are tetrachloroethylene (PCE), trichloroethylene (TCE), Aroclor 1254, and cadmium. The pyrophoric nature of the DU is also of primary concern. PCE and TCE detections range from non-detect levels to 20 weight percent and 1 weight percent, respectively. Aroclor 1254 analytical results range from non-detect to 1,700 parts per million (ppm). Toxicity Characteristic Leachability Test (TCLP) results for cadmium were observed at levels up to 35 milligrams per liter (mg/l).

Approximately 36 cubic yards of contaminated soil may be added to the DU waste stream described above. This soil is described as a gravelly clay and contains some debris (i.e., metal, plastic, etc.). The contaminated soils have been containerized in ten steel waste boxes (3.6 cubic yards each). The soils are contaminated with DU and organic compounds. U-238 was detected at activities ranging from less than 100 pCi/g to 4,000 pCi/g and PCE was detected at concentrations ranging from less than 1 ppm to 51 ppm. Aroclor 1254 was detected in nearly all soil samples collected, however, all concentrations reported were below the 50 ppm TSCA regulatory limit. The contaminated soils are not considered pyrophoric. The DU and soil wastes require treatment in accordance with Land Disposal Restriction (LDR) requirements for F001 and F002 wastes.

Waste Stream #2: Ten drums of cemented cyanide waste that were excavated from Trench 1 have been overpacked into steel drums. The cemented cyanide wastes are described as damp-to-wet unsolidified, granular, paste-like solids that contain asbestos fibers. Cyanide (total) contamination was detected in the waste from 0.5 to 5.3 percent by weight. The waste also exceeds regulatory thresholds for cadmium with TCLP cadmium concentrations ranging from 829 to 1,200 mg/l. The cemented cyanide wastes also contains low levels of uranium contamination. U-238 activities up to 117 pCi/g were observed in this waste stream. No volatile or semi-volatile organic compounds were detected in the

cemented cyanide waste. The cemented cyanide waste stream requires treatment in accordance with Land Disposal Restriction (LDR) requirements for F006 and F008 wastes.

As part of a market survey, RMRS is soliciting technical and regulatory permit information regarding onsite and offsite services and equipment that are appropriate for the treatment and disposal of the Trench 1 waste streams described above. This information shall include, but not necessarily be limited to: technical specifications, treatment process flowsheets, statements of qualifications, similar project experience descriptions, treatment system performance data, treatability testing capabilities, size reduction and materials handling equipment and capabilities, permits, and waste acceptance criteria (i.e., offsite facilities). The ultimate goal of treatment is to allow the wastes in question to be transported to an offsite, permitted facility for final disposal.

The waste streams, including secondary waste streams generated by any treatment processes, must be treated and disposed of by no later than September 30, 1999. Waste treatment may be performed at RFETS, but RMRS prefers for the waste to be treated at an off-site facility. If off-site treatment is proposed the submittal must describe the regulatory structure under which the waste will be treated; describe all required permits; include a corporate officer s certification stating all required permits are current and will be valid through September 30, 1999; include the facility s waste acceptance criteria; and include a copy of EPA s CERCLA off-site rule authorization letter.

Due to the nature of the work, RMRS is interested in proven technologies and methods for treating and disposing of the Trench 1 wastes described above. Demonstrated experience in treating and managing hazardous and radioactive wastes is necessary. A working knowledge of and demonstrated compliance with DOE, EPA, and OSHA regulations is also necessary.

This advertisement is NOT A SOLICITATION for services. Responses to this advertisement will be evaluated for the purpose of developing a list of vendors to which a Request for Proposal will be issued at a later date. All submittals shall be received no later than 4:30 P.M. (MST) on December 14, 1998. Submit responses and inquiries to Rocky Mountain Remediation Services, L.L.C., Rocky Flats Environmental Technology Site, P.O. Box 464, Golden, Colorado 80402-0464, Attention: Robert Cygnarowicz, Building T893B, (303) 966-7916.
CITE:

Appendix C

EVALUATION OF ONSITE TREATMENT ALTERNATIVES

for

TRENCH 1 RADIOACTIVE METAL AND SOIL WASTES

Appendix C
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C.0 EVALUATION OF ONSITE TREATMENT ALTERNATIVES FOR TRENCH 1 RADIOACTIVE METAL AND SOIL WASTES

The search for alternatives to treat Trench 1 (T-1) radioactive metal wastes and contaminated soils identified six onsite treatment alternatives (i.e., implementation at RFETS). These alternatives are evaluated in detail in this appendix with respect to their effectiveness in achieving regulatory-driven treatment goals as well as the challenges associated with implementing the alternative at RFETS. The evaluation concludes with a comparative analysis of the results of the evaluations which identifies two onsite alternatives with the most potential for onsite treatment of the T-1 wastes in question.

The vendors offering an onsite treatment alternative along with the treatment technologies included in the alternatives are summarized below.

Respondent	Proposed Treatment Technologies
GTS Duratek	Steam Reforming, Solvated Electron Dechlorination Technology, and Stabilization.
Materials and Energy Corporation	Solvent Extraction/Direct Chemical Oxidation, Thermal Desorption, and Stabilization.
Geosafe Corporation	Batch Vitrification.
ATG	Continuous Plasma Arc Vitrification.
Perma-Fix	Thermal Desorption, Direct Chemical Oxidation, and Stabilization.
Starmet	Solvated Electron Dechlorination Technology, and Thermal Oxidation

C.1 GTS Duratek

Process Description. GTS Duratek proposes that the radioactive metal and soil wastes be treated with a combination of steam reforming technology and solvated electron technology (SET) as illustrated by the process flowsheet presented in Figure 1. The flowsheet indicates that the mineral oil is first removed from the drummed waste. The solids are then "size reduced" and separated into various size fractions. Size reduction and separation activities are performed under an inert atmosphere because of the potentially pyrophoric nature of the DU wastes. Solids and debris larger than 6 cm are treated in the steam reforming unit. Solids less than 6 cm and liquids (including the mineral oil separated in the first step) are treated in the SET unit. The DU and soil wastes contained in B-12 and B-88 waste boxes are also treated in the SET unit. Following dechlorination in the SET unit, the solids are treated in the steam reformer where they are oxidized to eliminate the pyrophoric characteristic of the DU. The wastes are then stabilized to eliminate the toxicity characteristic associated with the leachability of cadmium. Empty drums and waste boxes are decontaminated to remove residual contamination and are subsequently managed as empty containers.

The steam reformer proposed by GTS Duratek is a batch process that consists of two primary units: an evaporator and a reactor. The evaporator unit employs superheated steam at approximately 1100 F to evaporate liquids and strip organic contaminants from the solid waste matrix. Chemical reaction between the high-temperature water vapor and the organic contaminants begins to occur in the evaporator which serves to crack heavier organic compounds into smaller, more volatile constituents. The degradation reactions are especially helpful in aiding the volatilization of PCBs (normal boiling point approximately 750 F) from the solid waste matrix.

The resulting steam and organic vapor mixture is drawn through a high temperature particulate filter and introduced into an electrically-heated reactor where the temperature of the vapor is raised to approximately 2,000 F. Water is extremely reactive at this temperature and the degradation reactions that begin in the evaporator unit are taken to completion. The result is a mixture comprised of simple gases such as hydrogen, carbon dioxide, carbon monoxide, methane, hydrochloric acid, ammonia, and water vapor. This offgas is quenched and treated appropriately prior to venting to the atmosphere.

The SET unit proposed by GTS Duratek is offered through Commodore Advanced Sciences, Inc. It is a pressurized, batch mixing unit that commingles solid wastes with a highly reductive liquid solution that serves to dechlorinate organic contaminants present in the waste. Each chlorine atom is displaced by a hydrogen atom, thus, transforming chlorinated organic compounds into non-regulated hydrocarbons. The reductive solution is formed by the dissolution of an alkali metal such as sodium in liquid anhydrous ammonia. The result is a solution charged with "solvated" or free electrons that are needed to drive the dechlorination reaction forward. Pressurization of the mixing unit is required to maintain the liquid state of the ammonia. After the dechlorination reactions are complete, the pressure is reduced to allow the ammonia to vaporize. The reaction products remaining in the solid waste matrix are dechlorinated hydrocarbons and chloride salts.

Process Evaluation. Both steam reforming (Gibson, 1997) and SET (Commodore, 1998) have been found to be effective in reducing the concentrations of chlorinated solvents and PCBs required to meet Land Disposal Restrictions. An important advantage of both treatment technologies is that the regulated organic contaminants present in feedstock wastes are eliminated. This is in contrast with a physical separation process that concentrates the contaminants in a secondary waste stream which must be further treated. In the case of steam reforming, the desorbed organic contaminants are destroyed to simple gases by reacting them with superheated steam. With SET, the regulated contaminants are transformed into non-regulated hydrocarbons. Steam reforming technology has the added advantage of oxidizing the DU (Waber, 1956), and thus, eliminating the pyrophoric nature of the wastes.

For these two treatment technologies to be effective, however, adequate surface area contact between the solid waste matrix and the reagent (i.e., superheated steam or solvated ammonia solution) is required. The proposed process addresses this need by crushing and fractionating the wastes prior to treatment. The larger size fraction is processed in the reformer unit where mechanical mixing is not available to expose waste surfaces. Smaller solids, sludges, soils, and oils are processed in the SET unit which provides mechanical mixing. There is uncertainty, however, that the degree of solid-reagent contact necessary for effective treatment will be achieved in the SET unit when processing oily sludges and pastes. "Channeling" is likely to occur in these wastes which will serve to limit the surface area of the solid waste exposed to the liquid reagent.

The proposed feedstock preparation activities should enhance the overall waste-reagent contact achieved in the treatment operation. As noted above, however, whether the feed preparation measures will be sufficient to ensure that treatment goals will be met is uncertain. Nonetheless, the proposed size reduction and size separation activities proposed for the T-1 wastes have three important disadvantages. These include worker exposure, equipment shutdown, and equipment decontamination. The potential for exposing workers to contamination is significant considering the need to transfer the wastes from the drums to the feedstock preparation equipment and from treatment unit to treatment unit.

It should also be noted that transferring the contents of approximately 25 drums will prove to be extremely challenging. The drums in question contain extremely hard DU metal wastes. Repeated blows with a non-sparking chisel were required to obtain samples from these drums. It is speculated that the DU waste chips placed in these particular drums have fused into hard monoliths as a result of oxidation. The hard and dense nature of the monoliths presents a considerable challenge with respect to removing the contents of the drum. The drum in which the wastes have been buried may have to be cut away from the contents which significantly increases the time that workers are in close proximity to the wastes.

In contrast, shredding entire drums along with their contents may decrease worker exposure to contamination by reducing the amount of manual handling required. A shredding operation may, however, increase the chance of equipment shutdown (e.g., jamming, plugging, etc.). In such an event, the benefit of reduced worker exposure gained by shredding would be offset by the exposure realized in resolving the cause of the shutdown and possibly making repairs to contaminated equipment. Even in the absence of a shredding operation, shutdown and damage to the size reduction equipment proposed, and subsequent worker exposure to make it operational, is of particular concern considering the fused DU wastes described above. Plugging of screening equipment by the oily sludges and pastes is also likely. The inerted atmosphere placed over the feed preparation operation is necessary to avoid pyrophoric reaction, but has the drawback of requiring workers to enter an IDLH (immediately dangerous to life and health) environment on supplied air to service equipment and for final equipment decontamination. Although workable, alternatives that do not present this situation must be seriously considered.

Manual decontamination of drums, drum debris (present in B-12 containers), waste boxes, and feed preparation and treatment units also provides opportunities for worker exposure. Also, the inability to adequately decontaminate feed preparation and treatment equipment for free release as a result of hard to reach surfaces would significantly add to the overall cost of the project.

The need for the aggressive feed preparation effort proposed by GTS Duratek must be examined with respect to steam reforming technology. Entire drums of waste have been successfully treated in steam reformers without the need to prepare the wastes (Synthetica, 1989). The obvious benefit is minimal materials handling and worker exposure (DOE, 1998). This approach depends on the ability of superheated steam at 1110 F to sufficiently penetrate the solid waste matrix and will, in large part, depend on the physical nature of the waste. To be certain, treatability studies must be performed for each waste stream. The need for treatability testing is acknowledged by GTS Duratek in their response to the CBD advertisement. In addition to the uncertainties associated with effective steam penetration in the dense DU solids and sludges, sludge-liquid contact in the SET unit must also be examined prior to implementation of this treatment alternative. The treatability effort would have to consider the physical variability in the waste stream. For example, a series of steam penetration tests must be examined to determine the effectiveness of the technology on oily sludges, pastes, and densely compacted solids.

Treatability tests must also be performed to support the stabilization operation. Specifically, testing must determine the appropriate "recipe" and waste loading for the effective stabilization of cadmium.

This evaluation concludes with mention of several operational hazards associated with the GTS Duratek treatment process. These include operation at high temperatures as well as the generation of flammable (i.e., hydrogen and methane) and acid (i.e., HCl) gasses in the steam reformer. The latter is extremely corrosive at the operating temperatures in question and can result in stress of system components. Volatility of uranium metal will not be an issue once the oxide is formed although radionuclide-contaminated particulate carryover from the evaporator unit to the reactor is of concern (DOE, 1998). The latter depends on the physical nature of the feedstock wastes and how they are physically affected by superheated steam. Hazards associated with SET unit include pressurized operation and mechanical movement.

C.2 Materials & Energy Corporation (M&EC)

Process DescriptionProcess Description. M&EC suggests that the radioactive metal and contaminated soil wastes be treated by solvent washing and vacuum-enhanced thermal desorption (TD), as illustrated by the flowsheet presented in Figure 2. The flowsheet shows that after the mineral oil is drained from each drum, radioactive metal and contaminated soil wastes are hand-sorted to remove large pieces and metal for special handling. Larger pieces are fed to an auger for size reduction and the remaining material is staged into the appropriate treatment volumes for processing. Per the flowsheet, the radioactive metal waste is first treated by solvent washing and then by TD to reduce the chlorinated solvents and PCBs to below treatment goals. Following treatment in the TD unit, the waste is solidified to remove the pyrophoric and toxic characteristics. Alternatively, feedstock soil is fed directly to the TD unit to desorb chlorinated solvents and PCBs to below treatment goals.

Waste liquids and sludge recovered during oil draining, solvent washing, and TD operations are treated by direct chemical oxidation (DCO), and the waste from the DCO unit is stabilized for land disposal. Containers are decontaminated with a non-hazardous solvent. The spent solvent is recycled to the solvent washing unit.

The solvent washing unit mixes a non-hazardous solvent with the radioactive metal waste, such that thorough and intimate contact is achieved, extracting the organic contaminants of concern into the solvent. The radioactive metal waste is allowed to settle prior to draining the solvent from the mixing tank, and the spent solvent is reclaimed by distillation using a batch still. This minimizes the quantity of the spent solvent requiring treatment for disposal. The wet radioactive metal waste is transferred to the TD unit for further treatment of the organic contaminants.

The TD system proposed is a batch unit that employs radiant heat and a sweep gas (i.e., air or inert gas) to volatilize organic contaminants from the wastes into the sweep gas. A high vacuum is applied to the desorber to enhance the volatilization of higher boiling point contaminants such as PCBs. The contaminant-carrying sweep gas from the desorber is filtered to remove particulates, chilled to recover organic constituents, and polished with activated carbon prior to atmospheric discharge.

Process EvaluationProcess Evaluation. The primary advantages of solvent washing are its simplicity, room temperature operation, and relatively high contaminant removal efficiencies for certain types of wastes such as granular solids and sands containing organic surface contamination. Solvent washing can also be very effective as a pretreatment step for significantly contaminated waste where removal of a major portion of the organic contaminants enables the overall treatment process to attain final treatment goals. Also, the solvents typically employed are non-hazardous and may be recovered and reused.

The effectiveness of solvent washing the T-1 oily sludges and pastes is uncertain, however. Particle size and porosity of the waste solids as well as any surface coatings and channeling may limit the solid-liquid contact achieved in the unit. The treatment approach suggested by M&EC addresses the need for solid-reagent contact (as well as solid-gas sweep contact in the TD unit) by sorting and size reducing the wastes prior to treatment. These feedstock preparation activities, which need to be performed in an inert atmosphere, should enhance the overall waste-reagent contact achieved in both the solvent washer and the TD unit. However, as discussed in Section 4.1 for the GTS Duratek process, size reduction and feed segregation of the T-1 wastes have several important disadvantages including worker exposure, equipment shutdown, and equipment decontamination. Entrainment of solids during solid-liquid separation, safety hazards associated with using solvents with pyrophoric material, and the generation of secondary waste streams (i.e., spent solvent and filter media) pose operational challenges with this technology.

The suggested process will experience difficulty in processing the radioactive metal and soil wastes contained in the B-12 boxes. If this material is processed in the solvent washer, a significant quantity of solid entrainment may be observed in the spent solvent which will cause problems in distillation and add to material handling problems of the secondary waste streams. Alternatively, the radioactive metal waste and soil could be manually segregated, with the metal waste going to solvent washer and the soil to TD unit. However, this will only increase worker exposure and it is suspected that the separation would not be complete enough to avoid the aforementioned problems associated with solids carryover.

There is an abundance of data demonstrating the performance of TD technology for removing chlorinated solvents. In fact, the TD unit proposed by M&EC has been successfully used three times at RFETS for desorbing TCE and PCE from soils (i.e., Ryan's Pit, Mound Site, and the Trench T-3/T-4 projects). TD technology has also been shown to be effective in the removal of heavier organic contaminants such as PCBs (i.e., less than 2 ppm) when high vacuums are applied (Mclaren Hart, 1998).

The pyrophoric nature of DU and the presence of PCBs in the wastes necessitates the use of an inert gas sweep. The presence of oxygen and PCBs at elevated temperatures may potentially result in the formation of dioxin and furan compounds. Treatability testing must be conducted to ensure that such reactions do not occur. Also, oils not removed in the solvent washer are susceptible to smoking, where the nature of the radiant heat source can lead to high localized waste temperatures and subsequent cracking of any oils present.

C.3 Geosafe Corporation

Process Description. Geosafe Corporation proposes that the T-1 radioactive metal and soil wastes be treated in a batch vitrification unit. The primary components of the unit are illustrated in Figure 3 and include a waste treatment cell, an offgas collection hood, and an offgas treatment system. The treatment cell is constructed of reinforced concrete and is typically poured below ground surface much like a

residential foundation. The bottom of the cell is "lined" with approximately three feet of compacted, clean soil. Drums and waste boxes containing the radioactive metal and soil wastes are placed on the soil liner in the center of the treatment cell. Mineral oil is drained from the drums prior to placing the drums into the cell. Contaminated soil from B-88 waste boxes or clean soil is then used to fill the void spaces inside and between the containers. Clean soil is then placed around and over the top of the drums and compacted with a backhoe or excavator. The clean soil buffer extends to the walls of the treatment cell.

After the treatment cell is loaded and compacted, an electrically-conductive graphite material is placed on top of the soil which provides the initial conductive pathway for the electric current that is necessary to begin the melt. The offgas collection hood is then placed over the cell and an array of four electrodes is inserted through the hood to the soil surface and graphite starter material. With the offgas treatment system is in place, electrical energy is applied to the starter material through the electrodes. The electrical energy is converted to thermal energy as it encounters resistance while traveling through the graphite. The heat released melts the graphite and adjacent soils. Once the melt is formed, it serves as the conductive pathway and heat source for the melt to grow. Soils and wastes adjacent to the melt are heated by conduction and subsequently melt when they reach the appropriate temperature. As the melt proceeds, the electrode array travels downward by gravity, delivering electrical energy throughout the volume of the melt. The power required to carry out the melt typically ranges from one to four megawatts depending on soil and waste type, waste loading, cell size, and desired processing time. The electrical energy is provided by a 13.8 kV supply line. The temperature of the melt typically ranges from 1,600 to 2,000 C.

The temperatures achieved in the melt serve to pyrolize organic contaminants and debris present in the soils and wastes to simple gases (e.g., carbon dioxide, carbon monoxide, simple hydrocarbons, water vapor, and hydrochloric acid). The offgas leaving the collection hood is filtered, quenched, scrubbed and polished with activated carbon prior to atmospheric discharge. Inorganic contaminants are oxidized and are chemically incorporated in the melt. After all wastes are melted, as indicated by the electrodes reaching the soil liner, the power is de-energized and the melt allowed to cool and solidify (several days). The resulting glass-like product is chipped out of the treatment cell and containerized for subsequent disposal. The treatment cell is charged with the next batch and the process repeated.

Process Evaluation. The batch vitrification process proposed by Geosafe has several important advantages with respect to the treatment of T-1 radioactive metal and soil wastes. First and foremost is the minimal amount of feed preparation and worker handling that is required. The process does not require that wastes be removed from their containers. The steel drums and waste boxes are melted along with the wastes in the treatment cell. Feed preparation consists of draining the mineral oil from the overpack drums, removing overpack drums and inner drum lids, filling void spaces within the primary containers with soil, and compacting the containerized material. The drums and boxes are also pierced to provide additional pathways for the vapors that are generated inside the containers to escape. The compacting and piercing activities are performed in the treatment cell with the aid of heavy equipment. In the event that pyrophoric activity is observed while preparing the batch charge, clean soil can be used to smother the reaction as was done during excavation. The residual mineral oil remaining on the solids should reduce the potential for pyrophoric activity relative to what was encountered during excavation.

Batch vitrification of the wastes takes place without the need for mechanical movement of feedstock wastes, reagents, or product (e.g., feed delivery, waste-reagent mixing, etc.). The absence of moving

parts greatly reduces the likelihood of a process shutdown, and thus, the need for operators to work on contaminated equipment during restart efforts. The blowers and pumps associated with the offgas treatment system are not immune to operating problems, however. Because these components are located downstream of the treatment cell, working on them should afford minimal exposure to contamination.

Other than the heavy equipment and associated compacting and piercing attachments, there is no equipment that comes in direct contact with the waste that would otherwise require decontamination at the conclusion of the project. While processing the last batch of waste, the melt is allowed to proceed through the soil liner and the bottom of the concrete treatment cell. As long as the clean soil buffer between the treatment area and the cell walls is maintained throughout the project, unmelted soil and the cell walls should not be contaminated. The cell walls can be broken and disposed as clean rubble or used as structural fill material.

As is the case with steam reforming and SET, vitrification has the benefit of eliminating regulated organic contaminants in one step. In addition, vitrification also has the benefit of stabilizing radionuclides and hazardous metals in this same step. The need to transfer the wastes to a cementation unit, for example, is eliminated. Stabilization is achieved by chemically incorporating the metals into the glass product. In order for a metal to be chemically incorporated into the glass matrix, it must be in the form of an oxide so that it is "compatible" with the chemistry of the melt (i.e., silicon and aluminum oxides). Fortunately, the thermodynamics at melt temperatures favors the formation of uranium oxide over the iron oxides present in the soils. Thus, the metallic uranium present in T-1 wastes will preferentially oxidize while the iron oxides present in the soil and wastes (e.g., corroded drums) are reduced to metallic iron. Once oxidized, the uranium is chemically incorporated into the melt and final glass product in the same manner that lead oxide is incorporated into glass crystal. Retention of radionuclides and hazardous metals in the melt may be adversely effected if the soils and wastes placed in the treatment cell do not possess a sufficient iron oxide content to ensure complete oxidation of all metallic uranium present in the wastes. In such cases, ferrous oxide can be mixed in with the native soils to ensure a stoichiometric excess of mineralized oxygen.

Bench-scale vitrification data indicate that as much as 99.99% of the uranium present in the feedstock wastes is retained in the final glass product (Hansen, 1991). Similar studies have indicated retention efficiencies as high as 99.99% for thorium as well (Hansen, 1991). Unfortunately, bench- and pilot-scale vitrification studies suggest only a 67 to 75% retention efficiency for cadmium, a semi-volatile metal. Volatilization of cadmium from the melt to the offgas is the biggest drawback of using batch vitrification for the treatment of T-1 radioactive metal and soil wastes. There are several measures that may be taken to achieve the highest possible retention of cadmium in the melt. First, a "extra thick" clean soil layer may be placed over the top of the wastes which will create a thick contaminant-free layer of molten material through which elemental cadmium will have to travel in order to volatilize to the offgas stream. The higher residence time in the melt increases the probability that cadmium will be converted to a non-volatile oxide and remain in the melt. A thick melt layer above the wastes will also serve to maximize the degree of organic contaminant pyrolysis achieved prior to volatilization from the surface of the melt. Second, the offgas scrubbing unit should be designed to maximize cadmium removal. Finally, the temperature of the melt should be maintained at the lower end of the vitrification temperature range to minimize the driving force for cadmium volatilization. Vapor bubbles generated within the melt from the volatilization and pyrolysis of residual mineral oil and organic compounds will offset these measures, however. Vapors traveling upward through the melt will serve to transfer contaminated melt upward as

well, effectively reducing the volume of melt that a contaminant must first migrate through prior to volatilizing to the offgas.

Another disadvantage commonly cited when considering vitrification for the treatment of hazardous and mixed wastes is the potential for pressurization of void spaces that may exist in the wastes matrix. Hot gases generated by the melt can accumulate in void spaces. If the space is large enough and sufficiently confined, violent release of accumulated vapor can occur in the melt. This phenomenon is of particular concern when attempting in place vitrification of buried wastes (i.e. *in situ*). In this case, it is difficult to know where void spaces may exist in the subsurface or within buried containers. In contrast, there is much more control and certainty in *ex situ* applications of this technology. As described above, excavated wastes are placed into a treatment cell in a controlled manner. Waste containers are opened and any void spaces present are filled with soil. The fill is compacted and the containers are pierced to provide vapor release pathways in addition to open top of the container. The latter measure is especially important considering that the melt progresses from the top to the bottom of the treatment cell.

Another drawback of batch vitrification is the generation of waste streams such as spent filter media, scrubber solution, and activated carbon. The technology does provide for the recycle of much of the secondary waste generated during a project to be recycled to the treatment unit. Unfortunately, this is not an option for the secondary wastes that are generated during the last batch processed.

The vitrified glass product is a superior waste form and is well suited for land disposal. Because the uranium, thorium, and cadmium are chemically incorporated into the product, leachability of these inorganic contaminants is essentially nonexistent as determined by TCLP analysis (Hansen, 1991). The glass product is also structurally sound and is reported to be approximately ten times stronger than unreinforced concrete.

From an implementation standpoint, the offgas collection and treatment equipment is readily available and transportable. The treatment cell is specifically designed and constructed for the application at hand. Treatability testing is necessary to support the design of the cell and preparation of the batch charges. Treatability testing allows determination of the proper waste loading and the necessity of introducing conductive and oxide additives to the native soils.

As noted above, the process requires one to four megawatts of power. Discussions with RFETS Engineering and Plant Power personnel indicate that the 13.8 kV overhead line at the T-1 project site is capable of supplying the required power.

C.4 Allied Technology Group (ATG)

Process Description. ATG proposes that the T-1 radioactive metal and soil wastes be treated in a continuous vitrification unit. As illustrated in Figure 4, electric power is delivered to the treatment unit in two forms. The first is an alternating current, similar to that employed in the Geosafe batch vitrification process, that is applied to the melt at the bottom of the unit. As described above, this electrical energy is converted to heat as resistance to the current flow is encountered in the melt. A second source of power, a high energy direct current, is applied in the vapor space directly over the surface of the melt. Unlike the flow of current through the conductive melt, the direct current energy arcs across the non-conducting air space, and in the process, creates an extremely high temperature plasma (approximately 12,000 C) . Radiant heat from the plasma also provides thermal input to the melt.

In practice, waste is continuously fed into the treatment chamber with an auger. The feed is directed through the plasma and into the melt. Pyrolysis of organic contaminants occurs in both the melt and the plasma arc. The elevated temperatures of the plasma ensure that the pyrolytic reactions are taken to completion to form carbon dioxide and hydrogen. The offgas from the plasma arc unit is treated prior to atmospheric discharge in a similar manner as described earlier for the batch vitrification process.

Under steady state operating conditions, the melt continuously exits the treatment unit through an overflow weir. The molten flow is directed into waste containers where it is allowed to cool and solidify. Metallic iron from the waste containers and the reduction of iron oxides in the feed soil (see Section 4.3) is similarly removed as it accumulates at the bottom of the treatment unit.

Process Evaluation. Many of the same assessments made in Section 4.3 for batch vitrification technology also apply to ATG's continuous plasma arc vitrification process. Both technologies offer the benefit of organic contaminant destruction and inorganic contaminant immobilization in one processing step. The feed must be properly prepared for both processes to achieve the proper waste loading, melt conductivity, and ferrous iron content. Both technologies produce the same superior waste form that is well-suited for land disposal. Finally, treatability studies are required in each case to obtain waste-specific performance data that allow the processes to be tailored to the waste treatment application. With these commonalities in mind, the remainder of this evaluation focuses on the important differences between ATG's continuous vitrification process and Geosafe's batch vitrification unit with respect to the treatment of T-1 wastes.

The degree of materials handling necessary to prepare the wastes for treatment constitutes an important difference between ATG's plasma arc process and Geosafe's batch vitrification unit. The continuous feed and processing requirements of the plasma arc process necessitates size reduction and blending of the wastes to ensure a successful operation. Such activities raise concerns of worker exposure and equipment downtime as discussed in other sections of this report regarding the technologies proposed by GTS Duratek, M&EC, and Perma-Fix. The ability to decontaminate the feed preparation equipment and feed auger for free release at the conclusion of the project is also uncertain.

Continuous processing does offer the opportunity for higher overall waste processing rates if the equipment can be kept operating. Specifically, production time is not lost while waiting for batches of vitrified waste to cool and solidify (days) and for the contents of a batch treatment cell to be manually broken apart and removed. The advantage of increased throughput achieved by continuous processing is not significant for the T-1 project, however, considering the relatively small volume of wastes that require treatment. In contrast, the risks associated with auger jamming and flow blockage are far more important.

Another critical disadvantage of the plasma arc process relative to batch vitrification is the potentially higher volatilization of cadmium (as well as uranium and thorium) resulting from the 12,000 C plasma. Treatability study data are required to evaluate this issue. Volatilization of cadmium may be further promoted by the relatively small volume of vitreous melt present in the plasma arc treatment unit. The smaller volume of melt may afford less opportunity for cadmium to oxidize which could lead to lower retention efficiencies of the metal. Moreover, the design of the plasma arc process does not provide for the development of a clean melt layer over the wastes as is the case in batch vitrification. As discussed above, a thick layer of clean melt will serve to increase the likelihood that cadmium vapor migrating to the surface of the melt will be condensed and converted to a non-volatile oxide. Of course, the duration that contaminated wastes are maintained at melt temperatures is, on average, shorter in a continuous

process than in a batch process. It should also be noted that the high temperatures present in the plasma arc will pyrolize organic contaminants more completely than in the batch process. This advantage is somewhat offset, however, by the ability to recycle secondary wastes in the batch vitrification unit.

C.5 Perma-Fix Environmental Services

As with M&EC, Perma-Fix suggests that solvent washing and TD technologies be used to remove organic contaminants from the T-1 radioactive metal and soil wastes (Figure 5). Likewise, cementation is proposed to solidify wastes prior to disposal. Description and evaluation of these technologies for the treatment of T-1 wastes need not be repeated. The reader is referred to the discussion and analysis presented in Section 4.2.

C.6 Starmet Corporation

Starmet proposes that the Trench 1 radioactive metal wastes be segregated into four groups and each group treated as follows:

Group	Waste Classification	Proposed Treatment Strategy
1	LLW	Treatment at Starmet's DU processing facility in South Carolina.
2	LLW/TSCA	Onsite treatment by SET followed by treatment at Starmet.
3	LLW/RCRA	Treatment at Perma-Fix in Gainesville, Florida.
4	LLW/RCRA/TSCA	Onsite treatment by SET followed by treatment at Perma-Fix.

Except for the DU ingot, all Trench 1 radioactive metal wastes are LLW/RCRA/TSCA and fall into Starmet's Group 4. The DU ingot is LLW and falls into Group 1. The choice to dispose of the DU ingot at NTS rather than have it processed at Starmet is based on economics. Likewise, the combination of onsite and offsite treatment proposed by Starmet for all other Trench 1 wastes is not economical. It makes far more sense to continue treatment through to its logical end once it is started as opposed to repackaging SET-treated DU wastes with fresh mineral oil and shipping to an offsite location to complete treatment. Also, there are several disadvantages with using SET to treat the Trench 1 radioactive metal wastes as described in Section 4.1. These include significant materials handling and worker exposure, the potential absence of adequate solid-liquid contact in an oily or pasty sludge (i.e., channeling), and equipment decontamination. Finally, as discussed in Section 3.2, Perma-Fix is not fully permitted to treat LLW/RCRA/TSCA waste at this time. Such a strategy would necessarily involve interim storage of the wastes for one to two or more years prior to treatment. The permit status of Perma-Fix was discussed earlier in Section 3.2.1.

C.7 Comparative Analysis

The evaluations presented above suggest that two technologies, steam reforming and batch vitrification, have the most potential for the onsite treatment of the T-1 radioactive metal and soil wastes. The distinguishing benefits of these technologies include minimal feed preparation and worker exposure and the destruction of organic contaminants in one processing step. Batch vitrification has the added advantage of immobilizing the inorganic contaminants into a superior waste form in this same processing step. There are uncertainties associated with the application of each of these treatment technologies to the T-1 wastes. In the case of steam reforming, for example, there is uncertainty regarding the ability of the steam to effectively penetrate the various solid waste forms without first size reducing and segregating the feedstock. Uncertainties regarding batch vitrification include hazards associated with void spaces present in the wastes, vaporization of semi-volatile metals, and formation of dioxin and furan compounds resulting from the partial oxidation of PCBs in the feedstock. Nonetheless, the evaluations suggest that immediate implementation of onsite treatment would best be pursued with the Geosafe batch vitrification process. The technical and operational issues associated with batch vitrification appear to be manageable through the design of the feed batch charge. Onsite implementation of batch vitrification is therefore examined below in more detail.

From an implementation standpoint, Geosafe Corporation appears to have a fair amount of operating experience with vitrification technology. The company has completed 85 large-scale melts comprised of approximately 22,000 tons of waste since 1993. These melts consist primarily of test demonstrations, but several full-scale remediation projects account for the balance. The latter includes the *in situ* and staged batch vitrification of hazardous wastes present at three EPA Superfund sites. Also, the company is currently involved in the *in situ* vitrification of 21 burial pits contaminated with plutonium and uranium at the Marlinga site in Australia. Treatment operations began at this site in May 1998, and since that time, 12 of the anticipated 26 melts have been completed. Geosafe also has experience working at the following DOE sites conducting bench-, pilot-, and demonstration-scale work:

Hanford	Large-Scale Demonstration	1989, 1990
INEL	Pilot-Scale Test	1987, 1990
Oak Ridge	Pilot-Scale Test	1987, 1991
Savannah River	Bench-Scale Test	1993
Brookhaven	Bench-Scale Test	1996
Oak Ridge	Large-Scale Demonstration	1996
INEL	Bench-Scale Test	1998

In addition, the company will begin a test demonstration at LANL in February 1999. The demonstration will involve two *in situ* large-scale test melts, the first in a "cold" area and the second in a "hot" area. The hot area is contaminated with several radionuclides including plutonium, uranium, americium, and cesium.

Final assessment of onsite batch vitrification for the treatment of T-1 wastes requires detailed evaluation of the process data generated by vitrification projects conducted to date. Analysis must focus on the physical and chemical nature of feed wastes processed, design of the batch charge, offgas analytical data, the necessity and required scope of treatability work, and operational and cost considerations. Additional analysis must also consider the costs associated with all RFETS-specific requirements that may apply to a vitrification operation (e.g., the need to conduct an environmental impact statement). Nonetheless, a

budgetary cost estimate for the onsite batch vitrification of T-1 radioactive metal and soil wastes has been prepared and is presented in Table C-1. The estimated cost of approximately two million dollars includes the preparation of project control documents (e.g., PAM, HASP, SAP, etc.), treatability testing, extensive analytical work, as well as contingency funds for unanticipated costs.

The schedule for planning and executing a batch vitrification project at RFETS is anticipated to be similar to that experienced for the thermal desorption treatment of Trench T-3/T-4 soils. The significantly smaller volume of wastes in the T-1 project will be offset by the unfamiliarity of the vitrification process to personnel at RFETS and the potential need to conduct a treatability test. Overall, a batch vitrification project, from planning to treatment to closure report preparation is expected to take approximately 15 to 18 months (see Table C-2).

Appendix C

TABLES

Table C-1

Budgetary Cost Estimate
Batch Vitrification of Trench 1 Wastes at RFETS

		Cost
I. Planning		
Document Preparation[1]		87,200
Ace Review		21,600
II. Treatability Study		
Plan Preparation		20,000
Pilot Vitrification		60,000
Test Report		16,000
Mobilization		
Transport and Assemble Equipment		220,000
Plant Power Modification		18,000
Cell Construction		30,000
Readiness Review		16,000
III. Treatment		
Treatment @ $2,000 per ton[2]		312,480
Electrical Power		N/A
Breakup and Containerize Product		15,000
RMRS Field Support		288,000
IV. Analytical		250,000
V. Demobilization		130,000
VI. Disposal		236,008
VII. Project Closure and Final Report		22,800
	Subtotal	1,743,088
	Contingency @ 15%	261,463
	Total Estimated Cost	**2,004,551**

Table C-1 (cont)

Budgetary Cost Estimate
Batch Vitrification of Trench 1 Wastes at RFETS

Cost Estimating Assumptions

[1]Includes the preparation of the following project-specific documents:

Proposed Action Memorandum (PAM), Field Implementation Plan (FIP), Integrated Work Control Package (IWCP), Design and Operating Plan, Hazard Analysis Report, Health and Safety Plan (HASP), and the Sampling and Analysis Plan (SAP)

[2]Treatment cost estimate is based on the vitrification of approximately 156 tons of radioactive metal and soil waste consisting of 130 overpack drums, 29 B-12 containers, and 11 B-88 containers. Cost estimate includes all associated field labor, health and safety, and radiological monitoring support.

Table C-2

Elapsed Schedule for Onsite Treatment of Trench 1 Radioactive Metal and Soil Wastes

Activity	Duration (months)
Procure Treatment Services Prepare Statement of Work Evaluate bids Negotiate and award subcontract	4
Project Documentation and Planning Proposed Action Memorandum Health And Safety Plan Field Implementation Plan Integrated Work Control Package Sampling and Analysis Plan APEN	3.5
Conduct Treatability Study	3[1]
Mobilization, Training, Setup, and System	1.5
Treatment and Waste Packaging	2
Decontamination/Demobilization	1
Waste Disposal	3
TOTAL DURATION	15-18

[1] If necessary.

Table 3-2
Permit and License Status of Offsite Commercial Facilities

Facility	RCRA Permit	RCRA Treatability Study Exemption	TSCA Permit	TSCA RDD Permit	Radioactive Materials License	CERCLA Off-site Approval	K/H Due Diligence	Clean Air Act Permit	All Req'd Equipment in Place	Presently Able to Treat T-1 Wastes?	Facility Storage Capacity/Presently Able to Store T-1 Wastes?
Materials & Energy Corp Oakridge, TN	Applied for in June 1998, Part B permit to include 7 processes (including capability to treat T-1 DU wastes); Permit expected in Summer 1999.	Could perform Treatability study; requires 45 day notification period to the State. Lab -scale equipment only.	Applied for in June 1998, Permit expected in Summer 1999.	No, not pursuing.	Presently operate under DOE Orders since facility is located at DOE Site; Radioactive Materials License applied for and approval is expected by 1/31/99. License will allow up to 80 Ci of DU material.	No	No	Expected in March 1999; not required to perform Treatability Study.	No	No, required Permits and Licenses are not in place.	Yes/No
ATG-Richland Richland, WA	Applied for RCRA/TSCA permit 2/98; Draft permit expected to be issued 1/99. Full permit issue expected in April 1999, Effective May 1999.	Could perform Treatability Study, however, ATG prefers to wait for issuance of Final Part B in May 1999	Permit expected in May/June 1999, permit will require thermal treatment for PCB's.	No	YES; can receive up to 10,000 kg of Source Material. Can submit project specific License Amendment to allow greater quantities of material-expect 3-4 weeks for Amendment Approval.	Yes	No	Expected to be issued with RCRA permit. Will require verification by K-H Compliance Group.	No	No; T-1 waste will exceed 10,000 kg requirement for Rad. Material License, additionally, RCRA/TSCA permits are not presently in place. Capability to treat T-1 cyanide wastes potentially in place by May 1999. Ability to treat T-1 DU wastes with Vitrification potentially by 1st QTR 2000. ATG must demonstrate process prior to full operation.	Yes/No
Perma-Fix Gainesville, FL	Yes; existing Part B permit allows for blending/bulking only; Revision to Part B will allow treatment-intent to issue expected Feb 99, then 45 day wait period	Could perform Treatability Study.	Application for Storage made in Fall 1998, approval expected Spring 99; No treatment Permit; but could depend upon National TSCA permit from other mobile unit.	YES, but must dispose at "pre-treated" levels.	YES; can receive up to 0.1 microcuries/gm for source material, and up to 200 nanoCi for DU. Can submit Project specific mod., expect 1-3 weeks.	Yes	Yes	Will require verification by K-H Compliance Group.	No	No; T-1 DU waste will exceed both specific activity requirements, RCRA/TSCA treatment permits are not presently in place. T-1 cemented cyanide wastes will presently meet WAC or could be accepted under a RCRA Treatability Study exemption.	Yes/Yes
DSSI Kingston, TN (liquid waste capability only)	Yes, existing permit is for liquids (<5 micron solids). Permit Modification for solid waste to be submitted 2/99. Approval of permit anticipated in 12-24 months. Permit will cover stabilization only.	Yes, could perform Treatability Study.	No, but could depend upon National TSCA permit from other mobile unit.	No	Yes, approved for Solidification Process only (up to 10,000 cubic feet per year).	Yes	Yes	Yes	Yes	Solid waste does not meet WAC; however, drained and bulked mineral oil should meet WAC.	No/No
Starmet, CMI Barnwell, SC	No	Yes, could perform Treatability Study.	No	No	Yes	Yes	Yes	Yes	Yes	No, Starmet cannot receive RCRA or TSCA wastes.	No/No
Waste Control Specialists Andrew, TX	Yes; permit allows for stabilization/solidification and chem. oxdn/redn. Permit modification required for treatment of T-1 DU wastes (add thermal desorb/oxdn estimate 12-24 months).	Yes, could perform Treatability Study of RCRA-only materials. Rad. License Amendment (2-3 months) required prior to accepting T-1 cyanide wastes.	No; Will submit TSCA permit application in Feb 99, anticipate 12 months for approval.	No	Yes; requires Amendment to allow for new treatment processes (i.e. chem oxdn., Thermal desorb., etc.) 2-3 months expected.	Yes	Anticipated 2/98	RCRA Part B permit incorporates Clean Air Provisions.	No	Not presently, RCRA/TSCA permit limited	Yes/Yes
Envirocare of Utah Clive, UT	Yes; permit allows for stabilization/solidification. Permit modification would be required for treatment of T-1 DU wastes (estimate 12-24 months).	Yes, could perform Treatability Study. Stabilization equipment available only.	No	No	Yes	Yes	Yes	Would require modification to permit for new treatment process.	No	No, Could not handle the TSCA-regulated materials. RCRA permit does not presently allow for required treatment processes to handle T-1 DU wastes.	No/No

Table A-1
Analytical Data Summary - Radioactive Metal Waste Stream

RIN	Location	Description	Container Type	Gamma Spec All Rad in pCi/g U-238	U-235	mass ratio 235/238	Isotopic AM-241	(c = composite) Activities in pCi/g Am-241	Pu-239/-240	VOCs in mg/kg PCE	TCE	TICs	SVOC (ppm)	PCB (mg/kg) A-1254	yrophoric DTA/TGA	Metals Concentrations in mg/kg Antimony	Arsenic	Barium	Beryllium	Cadmium	Chromium	Copper	Lead	Nickel	Selenium	Silver	Thallium	Vanadium	Zinc	Hg	TCLP for Cadmium (mg/L)
98A2105-001	X09832	Mixed soil + DU sampled high beta	B-12	9,770	106	0.17	ND	ND c	2.2 c	1.7	ND		Many low level detections			ND	14.5	65.3	ND	ND	ND	28.4	37.2	7.2	ND	4.7	ND	23.4	25.4	0.29	
98A2105-003	X09830	Black material	B-12	1,700	22.3	0.20	ND	ND c	2.2 c	0.06	ND		Many low level detections			ND	ND	60.1	ND	ND	ND	28.2	20.4	5.7	ND	6.5	ND	22	17.6	ND	
98A2105-005	X09835	Black powder maybe smoked	83-GAL OP	199,000	2,670	0.21	ND	0.16 c	ND c	86	0.26		Many low level detections			23.8	21.4	18.8	ND	ND	39.9	174.9	ND	ND	ND	67.7	ND	ND	ND	0.17	
98A2105-007	X09837	DU yellow/yellow green moist sticky	83-GAL OP	149,000	2,030	0.21	ND	0.14 c	0.19 c	50,000	2,600		Many low level detections		No	ND	ND	21	25.2	16.1	66.1	61.1	ND	13.9	21.9	ND	41.5	ND	41.7	0.16	
98A2105-009	X09840	Dry black powder	83-GAL OP	247,000	3,020	0.19	316.00	-0.17	0.13	20,000	300						Metals Analyses not Requested.														
98A2105-010	X09838	Wet Black powder + turnings	83-GAL OP	156,000	1,270	0.13	306.00	0.12	0.04	30000.00	9,800				No		Metals Analyses not Requested.														
98A2105-008	X09850	Black paste	83-GAL OP	200,000	1,460	0.11	ND	ND c	ND c	3000E	2,000				No		Metals Analyses not Requested.														
98A2105-013	X09843	Moist black powder + yellow + shiny cutting	83-GAL OP	192,000	1,100	0.09	ND	ND c	2.2 c	200000.00	10,000						Metals Analyses not Requested.														
98A2105-011	X09831	Small yellow + green DU + fillings	B-12	181,000	2,280	0.20	ND	0.07 c	ND c	1,000E	29.00		Many low level detection			ND	ND	19.5	ND	ND	54.3	33	24	9.8	ND	ND	ND	ND	37.1	0.16	
98A2105-014	X09825	DU black sludge + yellow + orange +	B-12	179,000	1,700	0.15	ND	0.07 c	ND c	10,000 B	400 J			95 D			Metals Analyses not Requested.														
98A2105-015	X09672	Wet black cohesive Tungsten confirmed	83-GAL OP	32,100	307	0.15	350	-0.01	0.43	20,000 E	1,000.00			60 D			Metals Analyses not Requested.													0.59	
98A2105-016	X09824	black + green	B-12	199,000	2,010	0.16	ND	0.07 c	ND c	3000.00	300.00						Metals Analyses not Requested.														
98A2105-017	X09667	Damp black powder cohesive	83-GAL OP	218000	2380	0.17	ND	0.16 c	ND c	7000.00	3,000.00		Many low level detection	22 D						926.9										0.16	35.06
98A2105-019	X09668	Damp Black granular + turnings	83-GAL OP	239000	1590	0.10	ND	0.16 c	ND c	3.10	0.09			4.3 D			Metals Analyses not Requested.														
98A2105-020	X09665	Saturated black wet , muddy oily	83-GAL OP	165,000	1,330	0.13	ND			10,000 E	400.00			340	No		Metals Analyses not Requested.														
98A2105-021	X09827	Metal turnings big springy green	B-12	229,000	1,920	0.13	ND			2.7 B	0.14			0.8	Pyro@>200		35.4U	17.7U		7.1U	17.7U		28.4U		42.5U	10.6U				
98A2105-022	X09677	Damp cohesive green DU	83-GAL OP	174,000	1,460	0.13	ND	0.07 c	ND c	20,000 E	100.00			430 D			Metals Analyses not Requested.														
98A2105-023	X09652	Peanut butter	83-GAL OP	Th-232 @ 19,709; U-238 @ 0				0.34 c	ND c	100 D	5.90		Many low level detection	2200			88.2U	44.1U	54.1B	17.6U	44.1U		70.5U		106U	26.4U				
98A2105-024	X09652	Peanut butter	83-GAL OP	Th-232 @ 18,348; U-238 @ 0						100 D	5.30		Many low level detection				95.4U	47.7U	56.9B	19.1U	47.7U		76.3U		114U	28.6U				
98A2105-026	X09828	DU metal turnings green + yellow	B-12	213,000	1,420	0.10		0.34 c	ND c	1.2 B	ND						Metals Analyses not Requested.														
98A2105-027	X09841	Green hard	83-GAL OP	237,000	1,670	0.11	0	-0.04	0.37	5.20	0.037 J						Metals Analyses not Requested.														
98A2105-028	X09669	Dry sticky black required mineral oil inert	83-GAL OP	222,000	1,760	0.12	ND	ND c	2.2 c	1.00	ND				At high temp		Metals Analyses not Requested.														
98A2105-029	X09670	Damp black powder	83-GAL OP	184,000	998	0.06	ND	0.16 c	ND c	10,000E	200.00			580 D			Metals Analyses not Requested.														
98A2105-030	X09894	Damp black powder	83-GAL OP	219,000	1,590	0.11	ND	0.16 c	ND c	4000.00	37 J		Phenanthrene > UTS	230 D			18.4U	13.4B		4.3B	9.2U		57.4		22.1U	36.2B				
98A2105-034	X09871	Dry black metal chips + green	83-GAL OP	256,000	1,550	0.09		0.27 c	0.5 c	3.00	0.032 J						Metals Analyses not Requested.														
98A2105-035	X09866	Damp black chips & turnings	83-GAL OP	80,100	540	0.14		0.07 c	ND c	500.00	ND						Metals Analyses not Requested.														
98A2105-036	X09845	Dark green/black + green powder	83-GAL OP	241,000	1,540	0.10		0.17 c	ND c	900.00	12 J						Metals Analyses not Requested.														
98A2105-037	X09844	Black patsy material no free liquid	83-GAL OP	197,000	2,740	0.22	ND	ND c	ND c	20,000E	200.00						Metals Analyses not Requested.														
98A2105-038	X09880	Dry Fine green chips + turnings	83-GAL OP	218,000	1,350	0.10	ND	0.14 c	0.19 c	1000 E	200.00		Naphthalene > UTS										205							ND	15.32
98A2105-040	X09823	Green rocky + peanut butter	B-12	Th-232 @ 4,107.1; U-238 @ 59,893				0.34 c	ND c	35.00	ND						Metals Analyses not Requested.														
98A2105-041	X09874	Dry granular yellow + green	83-GAL OP	207,000	1,810	0.14	ND	0.14 c	0.19 c	1.30	ND						Metals Analyses not Requested.														
98A2105-042	X09860	Dry cohesive	83-GAL OP	215,000	1,710	0.12	ND	-0.04	0.29	44.00	2.4 J						Metals Analyses not Requested.														
98A2105-043	X09862	Dry black chips + turnings	83-GAL OP	271,000	1,840	0.11	ND	0.27 c	0.5 c	ND	ND						Metals Analyses not Requested.														
98A2105-044	X09862	Dry black chips + turnings	83-GAL OP	274,000	1,560	0.09	ND			0.14 JB	ND																				
98A2105-045	X09884	Black chips + turnings	83-GAL OP	265,000	1,960	0.12	ND	0.17 c	ND c	0.055 JB	ND		Many low level detection												119.8						passed
98A2105-047	X09878	Green fine + shiny material	83-GAL OP	199,000	1,910	0.15	ND	-0.10	-0.45	2000 B	ND						Metals Analyses not Requested.														
98A2105-048	X09883	Black chips + turnings +brown+shiny	83-GAL OP	26,400	459	0.27	ND	0.17 c	0.59 c	3000 E	1,000.00						Metals Analyses not Requested.														
98A2105-049	X10058	Brown DU + green chips	110-GAL OP	268,000	2,320	0.13	ND	ND c	ND c	1.20	ND						Metals Analyses not Requested.														
98A2105-050	X09606	Yellow+green material	B-12	192,000	2,260	0.18	ND	0.17 c	0.59 c	20.00	0.18						Metals Analyses not Requested.														
98A2105-051	X09853	DU black chips + turnings	83-GAL OP	246,000	1,680	0.11	ND	0.27 c	0.5 c	2.50	.1 J		Many low level detection				19.4U	16.4B		3.8U	9.7U		20.5B		129	5.8U				
98A2105-053	X09855	DU black turnings + chips	83-GAL OP	258,000	1,900	0.11	ND	0.17 c	ND c	1.60	0.09						Metals Analyses not Requested.														
98A2105-054	X09879	black/green/yellow dry chips	83-GAL OP	250,000	1,920	0.12	ND	0.17 c	0.59 c	0.26	N.D.						Metals Analyses not Requested.														
98A2105-055	X09887	black turnings + chips+ dull green	83-GAL OP	253,000	1,650	0.10	ND	0.27 c	0.5 c	0.068 J							Metals Analyses not Requested.														
98A2105-056	X09882	Shiny black + dark green hard	83-GAL OP	162,000	1,420	0.14	ND	0.14 c	0.19 c	1.2 B	ND						Metals Analyses not Requested.														
98A2105-057	X09853	black chips	83-GAL OP	140,000	1,350	0.15	ND	0.27 c	0.5 c	14.00	0.10		Phenanthrene > UTS				low detections														
98A2105-059	X09854	soil+ Ice cream containers no DU	83-GAL OP	91,200	795	0.14	ND	0.17 c	0.59 c	9.3 BD	0.13 J						Metals Analyses not Requested.														
98A2105-060	X09876	Green + black + shiny	83-GAL OP	265,000	1,920	0.11	ND	0.17 c	ND c	0.29	ND						Metals Analyses not Requested.														
98A2105-061	X09857	Stainless + green DU	83-GAL OP	162,000	1,930	0.19	ND	0.17 c	0.59 c	11 BD	0.45						Metals Analyses not Requested.														
98A2105-062	X09886	Peanut butter	83-GAL OP	178,000	1,790	0.16	ND	ND c	ND c	0.86 B	ND						Metals Analyses not Requested.														
98A2105-063	X09888	Ice cream containers+ black DU chips + turnings	83-GAL OP	261,000	1,640	0.10	ND	0.17 c	ND c	0.17	ND		Low level detections, TICs			No significant metals detected															
98A2105-064	X09888	Ice cream containers+ black DU chips + turnings	83-GAL OP	258,000	1,380	0.08	ND			0.25	ND		Low level detections, TICs												47 U						
98A2105-066	X09885	black "pumice"/red DU powder	83-GAL OP	246,000	1,880	0.12	ND	-0.01	0.41	0.28 B							Metals Analyses not Requested.														
98A2105-067	X09864	Ice cream containers + soil +bright green DU	83-GAL OP	197,000	1,660	0.13	ND	0.14 c	0.19 c	1.3 B	ND						Metals Analyses not Requested.														
98A2105-068	X09863	liq pH=8, pumped liq, ice cream cont, black wet	83-GAL OP	2,920	21	0.11	ND	ND c	ND c	16.8 BE	0.71						Metals Analyses not Requested.														
98A2105-069	X09851	Ice cream cont. green granular DU	83-GAL OP	161,000	1,740	0.17	ND	0.04	0.51	3.1 B	0.096 J						Metals Analyses not Requested.														
98A2105-070	X09826	green granular DU	B-12	199,000	2,210	0.17	ND	0.80 c	0.22 c	0.06	ND		Low level detections, TICs				low detections														
98A2105-072	x09893	soil + dry ice cream cont. black chips + green	83-GAL OP	196,000	2,280	0.18	ND	ND c	0.20 c	1.00	ND						Metals Analyses not Requested.														
98A2105-073	X09875	liquid,ice cream cont., sand paper peanut butter	83-GAL OP	173,000	1,360	0.12	ND	ND c	0.20 c	2.60	ND						Metals Analyses not Requested.														

Table A-1 (cont)
Analytical Data Summary - Radioactive Metal Waste Stream

				Gamma Spec				(c = composite)						PCB		Metals Concentrations in mg/kg															TCLP for Cadmium
				All Rad in pCi/g		mass ratio	Isotopic	Activities in pCi/g		VOCs in mg/kg				(mg/kg)	yrophoric																
RIN	Location	Description	ContainerType	U-238	U-235	235/238	AM-241	Am-241	Pu-239/-240	PCE	TCE			A-1254	DTA/TGA	Antimony	Arsenic	Barium	Beryllium	Cadmium	Chromium	Copper	Lead	Nickel	Selenium	Silver	Thallium	Vanadium	Zinc	Hg	(mg/L)
98A2105-074	X09807	Green chips + turnings+black sludge	B-12	162,000.00	1,850.00	0.18	ND	ND c	0.38 c	0.21	ND						Metals Analyses not Requested.														
98A2105-075	X09856	Black chips + turnings+ soil +liquid drops	83-GAL OP	177,000.00	2,190.00	0.19	ND	ND c	0.38 c	0.49	ND						Metals Analyses not Requested.														
98A2105-076	X09890	LANL oil/ water drops+ green turnings	83-GAL OP	241,000.00	2,930.00	0.19	ND	ND	ND	0.9 JB	ND		Phenanthrene above UT	23 D	Stable <300C		low detections														
98A2105-079	D87702	Black paste + green	55-GAL OP	178,000.00	2,430.00	0.21	ND	ND c	0.011 c	0.37	ND						Metals Analyses not Requested.														
98A2105-080	X09842	liquid (pH=4), black paste peanut butter+turnings	83-GAL OP	164,000.00	1,850.00	0.18	ND	ND c	0.38 c	0.70	ND						Metals Analyses not Requested.														
98A2105-081	X09839	green granular + soil + green+black moist	83-GAL OP	192,000.00	2,730.00	0.22	ND	0.80 c	0.22 c	0.39	ND						Metals Analyses not Requested.														
98A2105-082	D88413	Green turnings + DU mixed soil+sparks	55-GAL OP	151,000.00	2,260.00	0.23		ND c	0.43 c	ND	ND	Fuel?		1.1			Metals Analyses not Requested.														
98A2105-083	D88407	hard dense green to black+ small turnings	55-GAL OP	169,000.00	2,410.00	0.22	ND	0.027 c	0.22 c				Naphthalene (5.0 ppm) > UT	15 D			low detections														
98A2105-085	D88417	black paenut butter	55-GAL OP	176,000.00	1,590.00	0.14	ND	ND c	0.011 c	0.38	ND			38 D			Metals Analyses not Requested.														
98A2105-086	D87699	liquids pH=7, top mud, du green peanut butter	55-GAL OP	179,000.00	2,530.00	0.22											Metals Analyses not Requested.														
98A2105-087	D88425	gry green springy	55-GAL OP	319,000	3,650	0.18		0.15 c	0.41 c	ND	ND	TICs		1.5			Metals Analyses not Requested.														
98A2105-088	D88387	Bright green springy turnings,sparks, DU damp	55-GAL OP	2.67E+05	3.67E+03	0.21		0.15 c	0.41 c	41.00	ND	Fuel?		6.2 D			Metals Analyses not Requested.														
98A2105-089	D88388	Dry springy turnings	55-GAL OP	326,000	4,060	0.19		ND c	0.49 c	ND	ND	TICs	detections, high TICs	1			low detections														
98A2105-091	D88418	DU + liquid not pumpable some soil	55-GAL OP	188,000	2,230	0.18		ND c	0.38 c	ND	ND	Fuel?		18 D			Metals Analyses not Requested.														
98A2105-092	D88414	Springy green turnings + liquid not pumpable	55-GAL OP	281,000	4,100	0.23		0.15 c	0.41 c	0.60	0.1 J	TICs		2.49			Metals Analyses not Requested.														
98A2105-093	D88410	Dry springy turnings	55-GAL OP	325,000	3,990	0.19		0.15 c	0.41 c	ND	ND	Fuel?		0.69			Metals Analyses not Requested.														
98A2105-094	D88415	Dry green springy turnings	55-GAL OP	332,000	3,740	0.18		ND c	0.43 c	0.13 J	ND	Fuel?		0.49			Metals Analyses not Requested.														
98A2105-095	D87710	Dark green chips + turnings	55-GAL OP	314,000	4,200	0.21		ND c	0.43 c	ND	ND	Fuel?	detections, high TICs	0.38			low detections														
98A2105-097	D88405	Dry green/yellow turnings, powdery top,moist low	55-GAL OP	180,000	2,720	0.24		0.80 c	0.22 c	0.14 J	ND	Fuel?		27 D			Metals Analyses not Requested.														
98A2105-098	D88416	Damp coarse turnings	55-GAL OP	180,000	2,470	0.21		0.027 c	0.22 c	1.20	ND	Fuel?		33 D			Metals Analyses not Requested.														
98A2105-099	D88412	Green/yellow dry turnings	55-GAL OP	312,000	4,070	0.20		ND c	0.28 c	0.90	ND	TICs		15 D			Metals Analyses not Requested.														
98A2105-100	D88412	Green/yellow dry*turnings	55-GAL OP	292,000	3,380	0.18				0.23	ND	TICs		5.9 D			Metals Analyses not Requested.														
98A2105-101	D88419	Dry green/yellow turnigs	55-GAL OP	331,000	3,740	0.18		0.15 c	0.41 c	ND	ND	Fuel?		0.68			Metals Analyses not Requested.														
98A2105-102	D88420	Dry green/yellow turnings	55-GAL OP	303,000	3,650	0.19		ND c	0.28 c	ND	ND	Fuel?	detections, high TICs	4.6 D			low detections														
98A2105-104	X09875	Coarse green turnings	55-GAL OP	244,000	2,360	0.15		ND c	0.28 c	ND	ND	TICs		0.27			Metals Analyses not Requested.														
98A2105-105	D88406	green/yellow dry turnings + lower damp	55-GAL OP	183,000	2,730	0.23		0.80 c	0.22 c	ND	ND	Fuel?		12 D			Metals Analyses not Requested.														
98A2105-106	D92869	green turnings lower slightly damp	55-GAL OP	168,000	4,070	0.38		0.80 c	0.22 c	ND	ND	Fuel?		28 D			Metals Analyses not Requested.														
98A2105-107	D92857	dry hard green/yellow+ lower moist black	55-GAL OP	299,000	3,430	0.18		ND c	0.20 c	2.10	ND	Fuel?		15 D			Metals Analyses not Requested.														
98A2105-108	D92858	black moist	55-GAL OP	168,000	2,270	0.21		0.027 c	0.22 c	0.14 J	ND	Fuel?	detections, high TICs	9.8 D			low detections														
98A2105-110	D92864	damp dark green to black granular	55-GAL OP	198,000	2,510	0.20		ND c	0.20 c	ND	ND	Fuel?		3.4 D			Metals Analyses not Requested.														
98A2105-111	D92854	damp dark green to black granular	55-GAL OP	218,000	2,770	0.20				0.47 J	ND	Fuel?		3.8 D			Metals Analyses not Requested.														
98A2105-112	D92860	Black paste	55-GAL OP	178,000	2,400	0.21		ND c	0.011 c	0.11 J	ND	Fuel?		11 D			Metals Analyses not Requested.														
98A2105-113	D92861	pH=5 liquid, black paste, high beta	55-GAL OP	174,000	2,300	0.21	ND	ND c	0.011 c	1.10	ND			7.4 D			Metals Analyses not Requested.														
98A2105-114	D92859	Black tarry sticky substance	55-GAL OP	168,000	2,290	0.21		ND c	0.011 c	0.10 J	ND	Fuel?		17 D			Metals Analyses not Requested.														
98A2105-115	D92865	Yellow-green turnings, powder, dry, sparks	55-GAL OP	338,000	3,000	0.14		ND c	0.49 c	0.082 J	ND	Fuel?	apthalene>UTS, high TI	1.1			low detections														
98A2105-117	D92868	Black powder, few fine turnings, dry, limited sparks	55-GAL OP	248,000	2,470	0.15		ND c	0.28 c	0.10 J	ND	Fuel?		2.9 D			Metals Analyses not Requested.														
98A2105-118	D92863	Yellow,green black turnings, damp, sparked	55-GAL OP	297,000	2,810	0.15		ND c	0.43 c	0.83	ND	Fuel?		5.8 D			Metals Analyses not Requested.														
98A2105-119	D92862	Yellow, green, dry turnings, sparked	55-GAL OP	304,000	3,250	0.17		ND c	0.49 c	0.04	ND	Fuel?		1.63			Metals Analyses not Requested.														
98A2105-120	D92854	Greenish black turnings, moist	55-GAL OP	178,000	2,290	0.20	ND	0.027 c	0.22 c	ND	ND	Fuel?		20 D			Metals Analyses not Requested.														
98A2105-121	D92855	Yellow-greenish turnings, dry, course, sparks	55-GAL OP	334,000	4,130	0.19	ND	ND c	0.49 c	ND	ND	Fuel?	Low level detections, TIC	0.93							151.9		111								passed
98A2105-123	D92870	Greenish to dark grey chips/granular moist	55-GAL OP	191,000	2,110	0.17	ND	0.027 c	0.22 c	ND	ND	Fuel?		4.5 D			Metals Analyses not Requested.														
98A2105-124	D92853	Yellow-greenish turnings, fine moderate sparking	55-GAL OP	322,000	4,090	0.20	ND	ND c	0.43 c	ND	ND	Fuel?		0.6			Metals Analyses not Requested.														
98A2105-125	D92871	Yellow-greenish turnings, course, fine, no sparks	55-GAL OP	305,000	4,520	0.23		0.15 c	ND c	1.2 D	ND	Fuel?		7.6 D			Metals Analyses not Requested.														
98A2105-126	D92868	Yellow-greenish turnings, course, fine, mod sparks	55-GAL OP	329,000	4,150	0.20		0.93 c	ND c	ND	ND	Fuel?		0.73			Metals Analyses not Requested.														
98A2105-127	D92852	Dark green turnings, fines, sparked- Los Alamos	55-GAL OP	336,000	4,090	0.19		0.28 c	0.86 c	0.57 J	ND	Fuel?	Low level detections, TIC	0.51									199							ND	passed
98A2107-129	D93262	Yellow-green course turnings, dry, sparks\, Los Alamos	55-GAL OP	314,000	4,200	0.21		0.28 c	0.58 c	0.33 J	ND	Fuel?		0.61			Metals Analyses not Requested.														
98A2105-130	D93269	Dry hard granular yellow-green + darker, Los Alamos	55-GAL OP	209,000	3,110	0.23		0.31 c	ND c	ND	ND	Fuel?		1.7			Metals Analyses not Requested.														
98A2105-131	D93264	Course dark geen + blackish turnings, dry on surface	55-GAL OP	325,000	4,200	0.20		ND c	0.28 c	ND	ND	Fuel?		0.35			Metals Analyses not Requested.														
98A2105-132	D93274	Dark green dry turnings, sparked	55-GAL OP	335,000	4,570	0.21		ND c	0.49 c	0.12 J	ND	Fuel?		1.5																	
98A2105-133	D93270	Dark green and black chip "peanut butter", no sparks	55-GAL OP	165,000	2,010	0.19		0.19 c	1.4 c	ND	ND	Fuel?	compounds > UTS	13 D			Metals Analyses not Requested.						120							ND	passed
98A2105-135	D93271	Black dry damp no sparking	55-GAL OP	215,000	3,580	0.26		0.07	15.00	ND	ND	Fuel?		ND			Metals Analyses not Requested.														
98A2105-136	D93276	black green and grey dry, sparking	55-GAL OP	328,000	3,890	0.18		0.28 c	0.58 c	ND	ND	Fuel?		7.2 D			Metals Analyses not Requested.														
98A2105-137	D93266	dark green, black cohesive, damp, no sparking	55-GAL OP	222,000	1,940	0.14		0.15 c	ND c	0.047 J	ND	Fuel?		14 D			Metals Analyses not Requested.														
98A2105-138	D93282	green/yellow timings damp, no sparks	55-GAL OP	174,000	2,060	0.18		0.04 c	ND c	0.054 J	ND	Fuel?		19 D			Metals Analyses not Requested.														

Table A-1 (cont)
Analytical Data Summary - Radioactive Metal Waste Stream

				Gamma Spec All Rad in pCi/g		mass ratio	Isotopic	(c = composite) Activities in pCi/g		VOCs in mg/kg				PCB (mg/kg)	yrophoric	Metals Concentrations in mg/kg													TCLP for Cadmium
RIN	Location	Description	Container Type	U-238	U-235	235/238	AM-241	Am-241	Pu-239/-240	PCE	TCE			A-1254	DTA/TGA	Antimony	Arsenic	Barium	Beryllium	Cadmium	Chromium	Copper	Lead	Nickel	Selenium	Silver	Thallium	Vanadium	Zinc	Hg	(mg/L)
98A2105-139	D93280	yellow/green turnings dry, sparks	55-GAL OP	206,000	2,930	0.22		0.93 c	ND c	ND	ND	Fuel?	A few low level detections	0.82									245							ND	passed
98A2105-141	D92856	black green yellow,moist, no sparks	55-GAL OP	245,000	3,540	0.22		0.03 c	ND c	0.12 JD	ND			10 D				Metals Analyses not Requested.													
98A2105-142	D93259	mud+peanut butter, no sparks	55-GAL OP	170,000	2,330	0.21		0.19 c	1.4 c	ND	ND	Fuel?		0.88				Metals Analyses not Requested.													
98A2105-143	D93261	fine yellow/green, sparks	55-GAL OP	340,000	4,800	0.21		0.28 c	0.58 c	0.043 J	ND	Fuel?		2.3				Metals Analyses not Requested.													
98A2105-145	D93263	black dry, sparked	55-GAL OP	249,000	2,680	0.17		0.04	15.00	ND	ND	Fuel?		1.5				Metals Analyses not Requested.					198								
98A2105-146	D92867	coarse green dry, sparked	55-GAL OP	333,000	4,410	0.21		0.28 c	0.58 c	ND	ND	Fuel?	Many low level detections	0.87																ND	passed
98A2105-148	D93273	coarse yellow/green no sparks	55-GAL OP	320,000	4,500	0.22		0.06 c	ND c	ND	ND	Fuel?		0.48				Metals Analyses not Requested.													
98A2105-149	D93265	dry black, sparks "copier toner"	55-GAL OP	339,000	4,150	0.19		0.13	23.00	0.120 J	ND	Fuel?		0.58				Metals Analyses not Requested.													
98A2105-150	D93275	coarse green dry, sparked	55-GAL OP	322000	3460	0.17		0.28 c	0.86 c	ND	ND	Fuel?		0.94				Metals Analyses not Requested.													
98A2105-151	D93268	black wet paste , no sparks	55-GAL OP	189000	2620	0.22		0.19 c	1.4 c	ND	ND	Fuel?		140 D				Metals Analyses not Requested.													
98A2105-152	D93281	mixed coarse, fine yellow, dry, sparked	55-GAL OP	323000	4150	0.20		0.93 c	ND c	ND	ND	Fuel?	A few low level detections	0.65									282							ND	passed
98A2105-153	D93281	mixed coarse, fine yellow, dry, sparked	55-GAL OP	313000	4420	0.22				ND	ND	Fuel?	A few low level detections	0.95									271							ND	passed
98A2105-155	D93272	black wet paste, saturated, no sparks	55-GAL OP	166000	2040	0.19		0.19 c	1.4 c	ND	ND	Fuel?		37 D				Metals Analyses not Requested.													
98A2105-156	D93267	black + green coarse turnings, dry, sparked	55-GAL OP	337000	3660	0.17		0.28 c	0.86 c	0.140 J	ND	Fuel?		ND				Metals Analyses not Requested.													
98A2105-157	D93278	coarse + turnings, dry sparked	55-GAL OP	333000	4290	0.20		0.93 c	ND c	ND	ND	Fuel?		0.38				Metals Analyses not Requested.													
98A2105-158	D93279	coarse green and dark turnings, dry, sparked	55-GAL OP	320000	4200	0.20		0.15 c	ND c	ND	ND	Fuel?		1.3				Metals Analyses not Requested.													
98A2105-159	D93283	black moist turnings, sparks	55-GAL OP	331000	4770	0.22		0.09	14.00	ND	ND	Fuel?	Naphth.=45 ppm, 2-meth	5.8 D									202							ND	4.23
98A2105-161	D93285	black moist turnings, chip, no sparks	55-GAL OP	247000	2630	0.17		0.04	15.00	ND	ND	Fuel?		3.6 D				Metals Analyses not Requested.													
98A2105-162	D93277	dry coarse green + black turnings, sparked	55-GAL OP	302000	3360	0.17		0.93 c	ND c	0.097 J	ND	Fuel?		0.37				Metals Analyses not Requested.													
98A2105-163	D93277	dry coarse green + black turnings, sparked	55-GAL OP	318000	4630	0.23				ND	ND	Fuel?		0.23				Metals Analyses not Requested.													
98A2105-164	D93287	black sticky paste "peanut butter" no sparks	55-GAL OP	172000	2190	0.20		0.19 c	1.4 c	ND	ND	Fuel?		ND				Metals Analyses not Requested.													
98A2105-165	D93286	moist, yellow + green, cphesive, dense, no sparks	55-GAL OP	182000	1960	0.17		0.06 c	ND c	ND	ND	Fuel?		50 D				Metals Analyses not Requested.													
98A2105-166	D93288	Dark green to brown/consolidated, no sparks, hard	55-GAL OP	2.07E+05	2.84E+03	0.17		0.03 c	ND c	0.04 JB	ND	Fuel?	Many low level detection	1.9									163								1.14
98A2105-167	D93288	Dark green to brown/consolidated, no sparks, hard	55-GAL OP	221000	2790	0.20				0.17 B	0.042 J	Fuel?	Many low level detection	2.3									147							ND	6.85
98A2105-169	D93284	Yellow/green coarse to fine, dry sparked	55-GAL OP	351000	3790	0.17		0.28 c	0.58 c	ND	ND	Fuel?		0.21				Metals Analyses not Requested.													
98A2105-170	D93280	Dry green/yellow, 4" wet, sparked	55-GAL OP	319000	2830	0.14		0.28 c	0.86 c	ND	ND	Fuel?		1.6				Metals Analyses not Requested.													
98A2105-171	D93462	Dry yellow/green turnings, no sparks	55-GAL OP	220000	2150	0.15		0.04 c	ND c	ND	ND	Fuel?		1.6				Metals Analyses not Requested.													
98A2105-172	X10374	Black/green tungins, dry, sparks	85-GAL OP	324000	3440	0.17		0.28 c	0.86 c	2000.00	ND	YES		ND				Metals Analyses not Requested.													
98A2105-173	X10371	Black, wet chips + powder, green/yellow no sparks	85-GAL OP	181000	2220	0.19		0.03 c	ND c	0.10 JB	ND	Fuel?	few low level detection	22 D									136							ND	1.14
98A2105-175	D93450	Wet, pH = 7 liq, 1-l, pumped, pasty gm/blk, no sparks	55-GAL OP	128000	1090	0.13		0.03 c	ND c	5000 DE	3.1	Fuel?		94 D				Metals Analyses not Requested.													
98A2105-176	X09806	Green/yellow granular damp slightly cohesive no sparks	B-12	173000	1770	0.16		0.04 c	ND c	54 E	0.22			97 D				Metals Analyses not Requested.													
98A2105-177	D93457	Green/black/brown granular turnings, damp, no spark	55-GAL OP	181000	3020	0.26		0.31 c	ND c	10000 E	22 J	some		62 D				Metals Analyses not Requested.													
98A2105-178	D93461	Green/yellow granular, damp, no sparks	55-GAL OP	171000	2050	0.19		0.06 c	ND c	10000 E	53 J	Fuel?		192 D				Metals Analyses not Requested.													
98A2105-179	D93466	Greenish, damp granular material, no sparking	55-GAL OP	205000	2610	0.20		0.15 c	ND c	3000 E	ND	some	2,3,4,6-Tetrachlorophenol	94 D							62.5									1.56	passed
98A2105-181	D93469	Greenish granular powder, no sparking	55-GAL OP	205000	2780	0.21		0.06 c	ND c	3000 BE	ND			80 D				Metals Analyses not Requested.													
98A2105-182	X10398	Green course, powder, some stainless steel?, spark	85-GAL OP	264000	4360	0.26		0.15 c	ND c	1000 B	ND			0.77				Metals Analyses not Requested.													
98A2105-183	X10375	Green granular, damp, no spark, some "graphite"	85-GAL OP	156000	2230	0.22		0.04 c	ND c	1000 B	ND	YES		140 D				Metals Analyses not Requested.													
98A2105-184	X09834	Green, yellow granules from 2 drums, moist no sparks	B-12	147000	1830	0.19		0.04 c	ND c	6000 BE	90			120 D				Metals Analyses not Requested.													
98A2105-185	X09833	Mostly dirt with green material (DU)	B-12	60000	752	0.19		ND c	ND c	0.62	ND	Fuel?	Phenanthrene > UTS	170 D							20.84			47 U					ND	passed
98A2105-187	X09829	Historic sample jar - uranium hydride	B-12	230000	9980	0.65		ND c	16 c	200.00	ND	Fuel?		ND			138				15	97		97 U					1.38	passed
98A2105-188	X10372	Dry light green chips+metal fragment	85-GAL OP	171000	2230	0.20		0.31 c	ND c	14 D	ND			100 D				Metals Analyses not Requested.													
98A2105-189	X09805	B-12 du + soil	B-12	64	2	0.50	ND	ND c	16 c	0.65	ND			0.17																	
98A2105-190	X09822	about 100 ml of DU + soil	B-12	6600	131	0.31	136 (Tungst	ND c	16 c	0.17	ND	Fuel?		140 D																	
98A2105-191	X09822	B-12 about 100 ml of DU + soil	B-12	7520	147	0.30	171 (Tungst	ND c	ND c	0.35	ND	some		110 D																	
98A2105-192	X09821	B-12 yellow + pale green DU + soil	B-12	141000	2420	0.27	nd	0.31 c	ND c	0.50	ND			ND			133				29	116		105 U					ND	passed
98A2105-194	X09798	B-12 Du granuals and fines (brightest green)+ soil	B-12	101000	1880	0.29	ND	0.03 c	ND c	1.80	ND		Many low level detections	1.1																	
98A2105-195	X09801	b-12 du chunks + soil	B-12	85400	1520	0.28	ND	ND c	ND c	2.40	ND	Fuel?	Many low level detections	250 D																	
98A2105-196	X09809	b-12 red/brown bDU chunks + soil	B-12	42300	768	0.28	ND	ND c	ND c	0.22	ND	some		10 D																	
98A2105-197	X09810		B-12	133000	2050	0.24	ND	0.06 c	ND c	0.31	ND	some		130 D																	
98A2105-198	X09800	B-12	B-12	96200	1590	0.26	ND	0.31 c	ND c	0.46	ND	some	Many low level detections	5.8 D			94 U				2270.89			113 U					ND	26.74
98A2105-200	X09804	B-12 dark brown/black du + soil	B-12	14300	269	0.29	ND	ND c	16 c	0.26	ND	some		6.0 D																	
98A2105-201	X09799	B-12 dark brown du + soil	B-12	1830	34	0.29	ND	ND c	16 c	0.88	ND			1.3																	
98A2105-202	X09803	B-12 Greenish and in chunks - no sparking	B-12	90600	1730	0.30	331 (tungst)	0.17	ND	1.80	ND	some		340 D																	
98A2105-203	X09829	Black cylindrical material -probable historic sample	B-12	156000	5280	0.53				0.23	ND	some		ND							LOW								ND		
98A2105-204	X09829	Marble size historic sample	B-12	329000	11100	0.52	ND			not enough sample				ND																	
98A2105-207	X09829	3" dia x 2" high dark green/yellow historic sample	B-12	1.24E+05	4.66E+03	0.58	ND			0.21 B	ND			ND							LOW								ND		

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Table A2 - Data Summary for Cemented Cyanide Wastes

RIN	Location	Description	Container Type	All Radionuclides in pCi/g U-238	U-235	U-235/238 Mass Ratio	Am-241	TCLP Failure	Total Cyanide (weight %)	Reactive Cyanide (ppm)	pH	Asbestos (vol %)	VOCs	SVOCs
98A2109-001	X10401	Top layer is white/grey/ yellow. Bot layer is grey/ green + slightly red/brown. Material saturated w/ liquid on surface. Pastey w/ fibers.	85-Gal OP	117.0	2.55	0.34	11.3U	Cd @ 829 mg/l	2.13	0.3	12.4	25	ND	ND
98A2109-003	X10397	Tan damp material, no liquid present.	85-Gal OP	84.8	2.42	0.44	10.8U	Cd @ 1,040 mg/l	1.85	ND	12.9	15	ND	ND
98A2109-004 (Duplicate of -003)	X10397	Tan damp material, no liquid present.	85-Gal OP	55.6	3.12	0.87	11U	Cd @ 1,200 mg/l	3.39	ND	13.2	Fibers Visible	ND	ND
98A2109-006	X10390	Off-white material/light gray at depth. Liquid present.	85-Gal OP	91.0	3.44	0.59	5.44U	Cd @ 972 mg/l	2.25	ND	12.8	Fibers Visible	ND	ND
98A2109-008	X10399	Off-white material. No liquid present. Pastey w/ fibers.	85-Gal OP	16.0	0.71	0.69	4.53U	Not tested	2.30			Fibers Visible		
98A2109-009	X10373	Off-white matl w/ brown liquid present on surface. Saturated paste. pH=13.	85-Gal OP	21.6	1.09	0.78	4.61U	Not tested	2.40			Fibers Visible		
98A2109-010	X10377	Hard brown/gray material. Wet pastes below surface.	85-Gal OP	59.9	0.986U	0.00	5.92U	Not tested	5.30			Fibers Visible		
98A2109-011	X10376	Tan wet paste. Liq on surface & in material. pH=13.	85-Gal OP	40.6	1.31	0.50	1.26U	Not tested	2.80			Fibers Visible		
98A2109-012	X10393	Hard tan material, greenish colored below surface.	85-Gal OP	8.1	0.193U	0.00	1.26U	Not tested	2.00					
98A2109-013	X10388	Dark green to off-white hard material.	85-Gal OP	26.4	0.944	0.56	1.18U	Not tested	0.54			Fibers Visible		
98A2109-014	X10382	Light tan/off-white wet paste.	85-Gal OP	81.8	2.38	0.45	1.95U	Not tested	0.51			Fibers Visible		

Table A-4
Analytical Data Summary - Decanted Lathe Coolant

All liquids in 55-gal poly drums

				All Rad in pCi/L		Mass Ratio			Fingerprint parameters					All Chemicals in mg/l					
RIN-Event	Location	Field OVA (ppm)	Field Description	U-238	U-235	U235/U238	AM-241	559 - g/L Pu	pH	flash point	spec gravity	miscible w/	Physical Desciption	PCE	TCE	TICs	Arochlor-1254	Cyanide	Metals
98A2106-001	X07938	not taken	single phase (with dark brown percip), yellowish	1,610.00	75.00	0.72	<68	<16000	6.5	NA-aqueous	0.9946	water	Single phase, non-viscous, transparent, colorless liquid	0.037	0.024		0.09 U	0.023	A few low detections
98A2106-002	X07927	115 PID	single phase, dark brown, oil sheen, half full drum	77,400.00	1,160.00	0.23	<270	35200	6.0	NA-aqueous	0.9963	water	Single phase, non-viscous, transparent, colorless liquid	0.25 UD	0.25 UD	Fuel?	0.21	0.077	A few low detections
98A2106-003	X07935	1500 FID, 350 PID	Bottom phase, dark greenish-brown - 3.5" (sample layered)	264,000.00	5,230.00	0.31	<591	Top=692000, Bottom=196000	5 - 6.5	NA-aqueous	about 1	water	Top layer: opaque, non-viscous, grayish liquid (3%), Bottom layer, transparent, non-viscous, colorless liquid (97%)	0.7 J	1.3 U	Fuel?	76 D	0.072	A few low detections
98A2106-004	X07935	1500 FID, 350 PID	Top phase, medium brown/tan - 6.5"	125,000.00	1,510.00	0.19	<391	58900	NA	77.3 C	0.8106	organics	single phase, slightly viscous, transparent, light yellow liquid	2.400	1.3 U	Fuel?	112 D	0.117	A few low detections

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